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Preliminary

Document No.: 1508-USM-01-0-01

Firmware: Version 1.0

User Manual

Edition One - July 2005

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Safety Instructions / Warning - Read before start-up!

- The device may only be used for the intended purpose designed by for the manufacturer. The operation manual should be conveniently kept available at all times for each user.
- Unauthorized changes and the use of spare parts and additional devices that have not been sold or recommended by the manufacturer may cause fire, electric shocks or injuries. Such unauthorized measures shall exclude any liability by the manufacturer.
- The liability-prescriptions of the manufacturer in the issue valid at the time of purchase are valid for the device. The manufacturer shall not be held legally responsible for inaccuracies, errors, or omissions in the manual or automatically set parameters for a device or for an incorrect application of a device.
- Repairs may be executed by the manufacturer only.
- Only qualified personnel should carry out installation, operation, and maintenance procedures.
- Use of the device and its installation must be in accordance with national legal requirements and local electrical codes.
- When working on devices the valid safety regulations must be observed.

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Preface

Read This First

About This Guide

This manual describes the ACG HF Multi ISO Reader Module. Its goal is to describe the reader, how it works, how to integrate it and how to use it.

If You Need Assistance

Our application center is located in Europe to provide direct support. For more information, please contact your nearest ACG Sales Center. The contact addresses can be found on our home page:

http://www.acg.de

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1 Scope

The ACG HF Multi ISO Reader Module supports a broad range of tags compliant with ISO 14443 type A and B standards, including SR176 tags, tags which belong to the Philips Mifare® family, ISO 15693 tags, ISO 18000-3, EPC and UID tags. An open command structure allows the device to communicate with tags that use an operating system. The read/write unit supports ISO 14443-4 layer with automatic chaining, 256 byte buffer and frame length, extended time framing and up to 848kBaud transmission rates over the air interface.

Additionally this unit implements a DES cipher which enables to use Mifare® DESFire tags. These tags are designed for use in high security algorithms.

A SAM interface is also available.

Major applications are:

- Access control, identification using high security cards
- Ticketing using standard Mifare® cards
- Data storage
- Multi-applications using operating systems

2 Extended Documentation

Please note that all confidential material is excluded from this documentation.

You can obtain the extended documentation containing the confidential information after signing a NDA.

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3 Definitions and Abbreviations

3.1 Definitions

3.1.1 Anti-collision loop

An algorithm used to identify and handle a dialogue between a reader and one or more tags in its antenna field.

3.1.2 Hex notation

A hexadecimal value is marked with the suffix ‘h’, i.e. A1h has the value A1 hexadecimal.

3.1.3 ASCII notation

ASCII characters are listed within apostrophes, i.e. ‘x’ means a single x.

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3.2 Abbreviations

Abbreviation	Description
AID	Application ID
ASCII	American Standard Code for Information Interchange
ATR	Answer to Reset
ATS	Answer to Select
AFI	Application Family Identifier
block	For the Mifare® Standard one block contains 16 bytes
CBC	Cipher Block Chaining
CID	Card Identifier (logical card address, ISO 14443-4)
CRC	Cyclic Redundancy Check
DES	Data Encryption Standard, for more details about DES refer to [3].
DSFID	Data storage format identifier
EDC	Error Detection Code
EGT	Extra Guard Time
EOF	End of Frame
ETU	Elementary time unit
hex / xxh	Value in Hexadecimal notation
I-block	Information block
KTT	Key Transfer Transponder
LSB	Least Significant Bit or Byte
MSB	Most Significant Bit or Byte
NAD	Node Address (ISO 14443-4)
OSI	Open System Interconnection
OTP	One time programmable
PCB	Protocol Control Byte (ISO 14443-4)
PCON	Protocol Configuration byte of the reader
PPS	Protocol and Parameter Selection
RATS	Request for Answer to Select
R-block	Receive ready block
REQA	Request ISO Type A
REQB	Request ISO Type B
RFU	Reserved for Future Use

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Abbreviation	Description
S-block	Supervisory block
sector	For the Mifare® Standard one sector contains 4 blocks
SID	Station ID
SFGT	Guard time after RATS
SN	Serial Number of a tag (a 32 bit number)
SOF	Start of frame
TDES	Triple DES
value block	32 bit data block format. Used in ticketing application
<CR>	Carriage return (0Dh)
<LF>	Line feed (0Ah)

Figure 3-1: Abbreviations

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4 Supported tags

	Manufacturer	Serial number	Read block	Write block	Transfer command	Comments
ISO 14443 A						
Mifare Standard	Philips	√	√	√	√	
Mifare 4k	Philips	√	√	√	√	
Mifare Ultralight	Philips	√	√	√	√	
Mifare ProX	Philips	√	√	√	√	
DESFire	Philips	√	-	-	√	encryption included
SLE66CLX320P	Infineon	√	-	-	√	encryption not included
SLE 55R04 / 08	Infineon	√	-	-	√	encryption included
Smart MX	Philips	√	-	-	√	
Jewel Tag	Innovision	-	-	-	√	works only with ‘t’ command
ISO 14443 B						
SLE6666CL160S	Infineon	√	-	-	√	
SR176	STM	√	√	√	√	
SLIX 4K	STM	√	√	√	√	
ASK GTML2 ISO	ASK	√	-	-	√	
ASK GTML	ASK	√	-	-	√	extended setup needed
Sharp B	Sharp	√	-	-	√	
TOSMART P064	Toshiba	√	-	-	√	
Dual Interface						
ISO 14443 A compliant ([1])	various	√	-	-	√	
ISO 14443 B compliant([1])	various	√	-	-	√	

Figure 4-1: Supported labels (Part 1)

[1] Performance varies

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	Manufacturer	Serial number	Read block	Write block	Transfer command	Comments
ISO 15693						
EM 4135	EM Microelec.	√	√	√	√	
ICODE® SLI	Philips	√	√	√	√	
LRI12	STM	√	√	√	√	
LRI64	STM	√	√	√	√	with 10% modulation index
LRI512	STM	√	√	√	√	
SRF55VxxP	Infineon	√	√	√	√	
SRF55VxxS	Infineon	√	-	-	√	encryption included
Tagit® HFI	TI	√	√	√	√	
Tagit® HFI-Light S	TI	-	-	-	√	only in addressed mode
TempSense	KSW	√	√	√	√	temperature logging
ICODE®	Philips	√	√	√	√	
ICODE® EPC	Philips	√	√	√	√	
ICODE® UID	Philips	√	√	√	√	

Figure 4-2: Supported labels (Part 2)

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5 The Mifare Transponder Family

The Mifare transponder family consists of various 13.56 MHz transponder ICs, all compliant to the ISO 14443 standard.

5.1 Mifare Standard

The Mifare Standard card consists of 16 sectors. A sector includes four blocks of 16 bytes each.

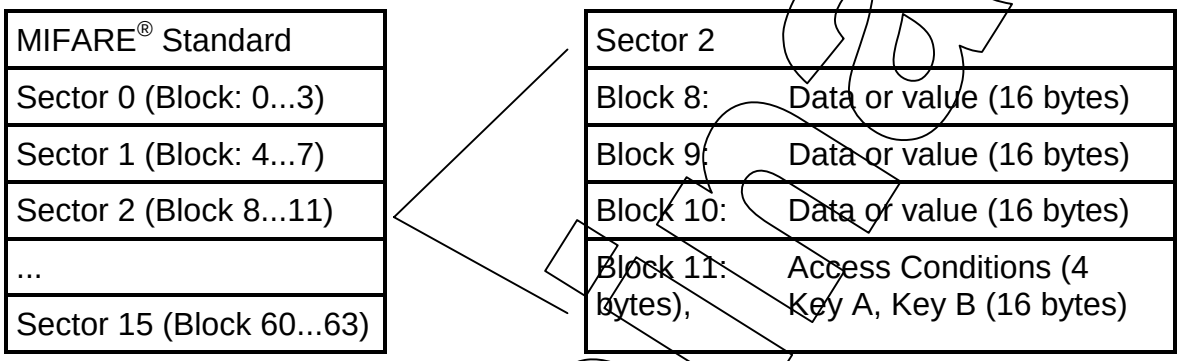
MIFARE® Standard
Sector 0 (Block: 0...3)
Sector 1 (Block: 4...7)
Sector 2 (Block 8...11)
...
Sector 15 (Block 60...63)
Sector 2
Block 8: Data or value (16 bytes)
Block 9: Data or value (16 bytes)
Block 10: Data or value (16 bytes)
Block 11: Access Conditions (4 bytes), Key A, Key B (16 bytes)

Figure 5-1: MIFARE® Standard: sector diagram

5.1.1 Sector 0 / Block 0

Block 0 is read only.

Serial Number (4 bytes)	Check byte (1 byte)	Manufacturer data (11 bytes)

Figure 5-2: MIFARE Standard: sector 0 / block 0

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5.1.2 Blocks 3, 7, 11, 15, …

Transport keys are set on delivery:

Key A (6 bytes)	Access Conditions (4 bytes)	Key B (6 bytes)

Figure 5-3: MIFARE® Standard: block 3, 7, 11, 15, …

Key A

A0 A1 A2 A3 A4 A5 (Infineon) or FF FF FF FF FF FF (new Philips cards)

Key B

B0 B1 B2 B3 B4 B5 (Infineon) or FF FF FF FF FF FF (new Philips cards)

Access Conditions

FF 07 80 xx (key A is used to read or write; key A itself is not readable; key B is data only). For further information refer to the Mifare card manual.

Remarks

Enabled keys are always read as 00 00 00 00 00 00

Using key B as a data area will cause a security gap, due to the fact that it is necessary to rewrite key A and the access conditions at each write process. It is not recommended to use key B as a data storage area.

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5.2 State Diagram

All Mifare cards use the following state diagram.

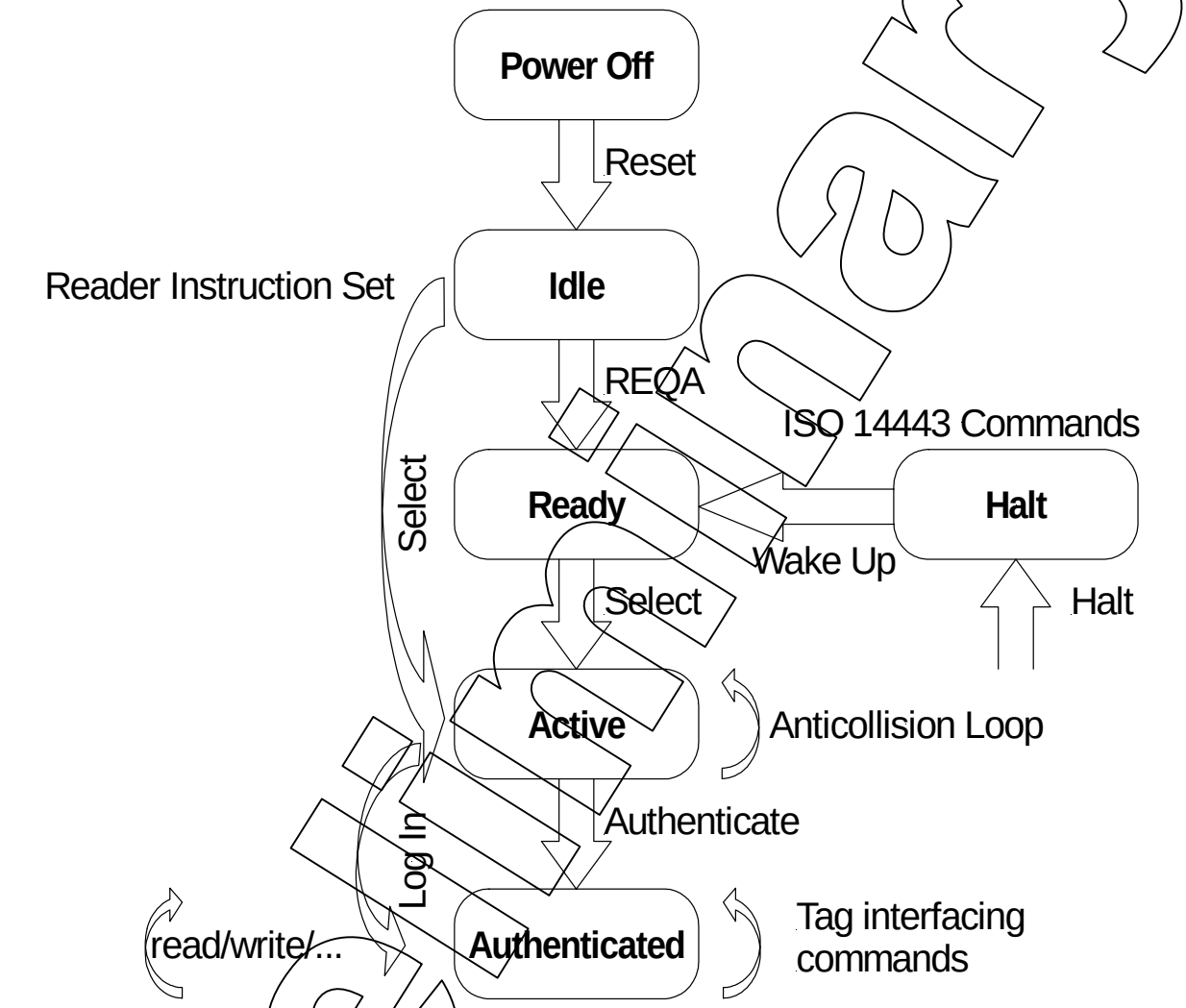

Figure 5-4: State diagram

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5.3 Mifare Ultralight

Mifare Ultralight cards have no encryption included. They only support plain text data transmission.

Mifare Ultralight only supports 4 bytes per sector, but the command set uses 16 bytes per sector. Only the 4 least significant bytes are valid when using Mifare Ultralight.

Ensure that the other bytes match with the tag content when using the write command; otherwise the read back will fail.

5.4 Mifare 4k

Mifare 4k cards have an increased memory. Beginning from sector 32 (20h), sectors have 16 blocks. Due to compatibility reasons, the sector indices have changed according to the following table. The login sector has to be used to access the corresponding sector on the card.

Sector	Block	Login sector
00h	00h – 03h	00h
01h	04h – 07h	01h
…	…	…
1Fh	7Ch – 7Fh	1Fh
20h	80h – 8Fh	20h
21h	90h – 9Fh	24h
22h	A0h – AFh	28h
23h	B0h – BFh	2Ch
24h	C0h – CFh	30h
25h	D0h – DFh	34h
26h	E0h – EFh	38h
27h	F0h – FFh	3Ch

Figure 5-5: Mifare 4k sector index table

5.5 Mifare ProX

Mifare ProX tags have an operating system onboard. Data organization depends on the operating system installed on the card. These cards can include additional functionalities such as DES or a proprietary encipher algorithm.

Before accessing the operating system, the card must be selected. Customized commands are issued using the transfer command.

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5.6 Mifare DESFire

This tag supports additional security algorithms (DES, Triple-DES, MAC) for security sensitive applications.

DESFire tags are addressed using a specific command set (see DESFire command set).

5.6.1 Memory organization

The memory of a DESFire card can be personalized to specific requirements. The card can be seen as data storage device like a hard disk in a PC. The memory is divided into a maximum of 28 different applications (directories) with 16 files each. An application has up to 14 keys. Depending on keys and access conditions a file can be accessed in four different ways. Plain data is never secured. Data is secured using a MAC, single DES or triple DES enciphers.

The following figure describes the memory organization of a DESFire card.

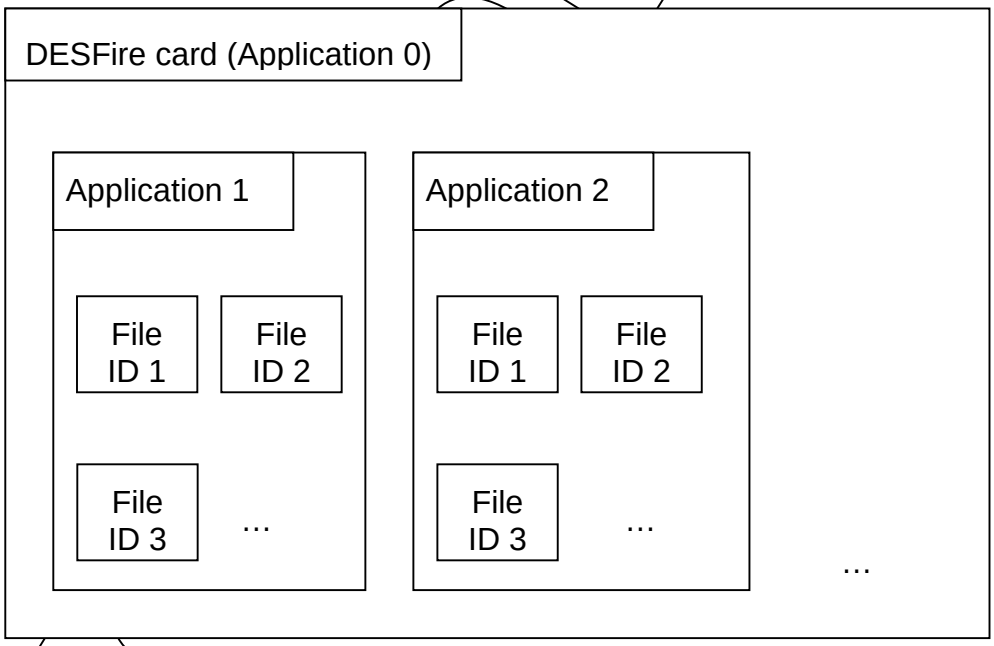

Figure 5-6: DESFire memory organization

PHILIPS

5.6.2 State diagram of DESFire

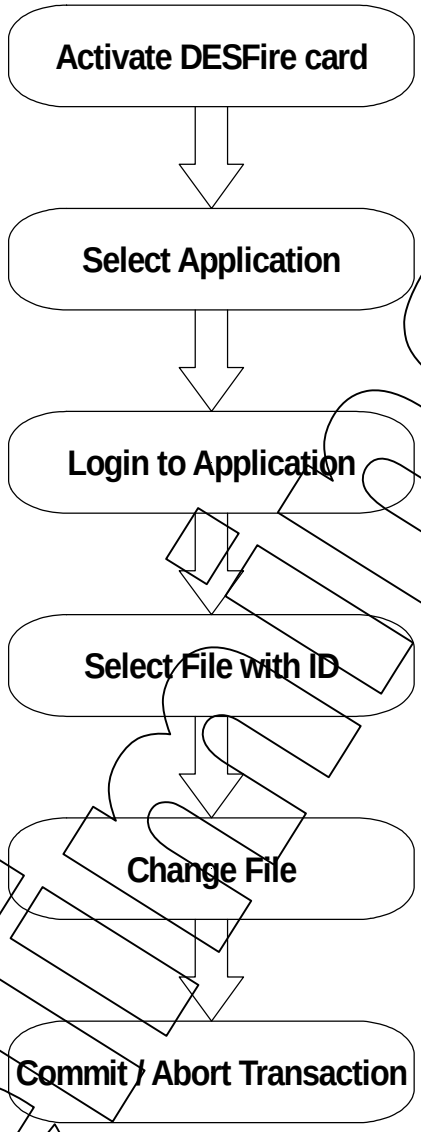

Figure 5-7: DESFire state diagram

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5.6.2.1 Activate PICC

Before accessing a DESFire card, the card must be selected. A DESFire card has a 7 byte UID. After activation, the card is powered up and ready to accept a DESFire command. Application 0 is selected automatically.

5.6.2.2 Select application

To jump into another application, the application has to be selected. An application can be seen as a directory, which contains up to 16 files. The size of the application depends on the stored files.

5.6.2.3 Login to application

Specific access rights can be set for each application. Login to an application allows changing the organization of the application. Login to a file opens a secured file for access. A file can be accessed in four different ways: without any security or secured with MAC, single DES or triple DES.

5.6.2.4 Select file

Before accessing a file, the file must be selected

5.6.2.5 Change file

A selected file can be changed according its access rights. If a file is secured, a login is required before changes can be made.

5.6.2.6 Commit / Abort transaction

Value files, backup files, linear record files and cyclic record files only adapt their values after the commit transaction command is given. Several files can be changed within an application at the same time. The abort transactions command annuls all changes within an application. Power loss will cancel all modifications too.

For more details about application settings and access rights refer to [2].

Preliminary

5.7 my-d IC (SLE 55Rxx)

my-d ICs are specific ICs from Infineon. These labels show a different memory organization. Two different modes of tags are supported: plain and secure mode.

Memory Size of SLE Rxx-family

Type	User Memory	Administration Memory	Number of pages
SLE 55R01	128 Bytes	32 Bytes	16
SLE 55R02	256 Bytes	64 Bytes	32
SLE 55R04	616 Bytes	154 Bytes	77
SLE 55R08	1024 Bytes	256 Bytes	128
SLE 55R16	2048 Bytes	512 Bytes	256

Address	Byte number within a page												
	0	1	2	3	4	5	6	7					
FFh	User data												
…	…												
7Fh	User data												
…	…												
4Ch	User data												
…	…												
1Fh	User data												
…	…												
0Fh	User data												
…	…												
04h	User data												
03h													
02h													
01h													
00h	Serial number (UID)												

SLE 55R01 SLE 55R02 SLE 55R04 SLE 55R08 SLE 55R16

Figure 5-8: SLE 55Rxx memory organization

Preliminary

6 ISO 14443 Type B

ISO 14443 type B cards are supported.

6.1 SR176

The SR176 label contains only 30 bytes of data organized in two bytes per page.

6.1.1 Memory organization

Block address	Byte 1	Byte 0	
0Fh	Lock byte	RFU	Chip ID
0Eh	User data		
…	…		
04h	User data		
03h	Serial number		
02h	Serial number		
01h	Serial number		
00h	Serial number		

Figure 6-1: SR176 memory organization

6.1.2 Serial number UID

The UID is stored in the first 4 pages. Page 00h contains the LSB of the UID.

Page 03h		Page 02h		Page 01h		Page 00h	
Byte 1h	Byte 0	Byte 1	Byte 0	Byte 1	Byte 0	Byte 1	Byte 0

Figure 6-2: SR176 Serial number

Preliminary

6.1.3 Lock byte

The lock byte defines the write access condition of a pair of pages. Each bit can only be set once. This procedure is irreversible. This byte is implemented as an OTP.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Page 0Eh Page 0Fh	Page 0Ch Page 0Dh	Page 0Ah Page 0Bh	Page 08h Page 09h	Page 06h Page 07h	Page 04h Page 05h	Page 02h Page 03h	Page 00h Page 01h

Figure 6-3: Lock byte

6.1.4 Chip ID

The Chip ID is defined in the low nibble of page 0Fh. It is manufacturer set and is used internally to select and separate single tags.

6.2 SRIX4K

The SRIX4K label contains 512 bytes of data organized into four-byte pages.

6.2.1 Memory organization

Block address	Byte 3	Byte 2	Byte 1	Byte 0
FFh	OTP Lock Reg	ST Reserved	ST Reserved	Fixed Chip ID
7Fh	User data			
…	…			
07h	User data			
06h	32 bits binary counter			
05h	32 bits binary counter			
04h	32 bits Boolean Area			
03h	32 bits Boolean Area			
02h	32 bits Boolean Area			
01h	32 bits Boolean Area			
00h	32 bits Boolean Area			

Figure 6-4: SRIX4K memory organization

6.2.2 Lock block

Locking of blocks is not supported with this tag.

Preliminary

7 ISO 15693

The reader can communicate with ISO15693 tags. An anti-collision is needed if multiple instances of tags are in the same antenna field. The reader detects each type of ISO15693 labels and handles them individually

7.1 Coding of UID

The UID of a tag is defined in ISO/IEC 15693-3. All tags compliant to ISO15693 support the specified format. The UID is factory programmed and cannot be changed. The UID is needed for the anti-collision sequence to separate several tags in the same antenna field.

Byte							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
E0h	MFR Code	Serial number					

Figure 7-1: Coding of ISO 15693 UID

The MFR Code is listed in ISO/IEC 7816-6:1996/Amd.1: 2000(E). Following manufacturer are tested with our reader

MFR-Code	**Company**
02h	ST Microelectronics
04h	Philips Semiconductors
05h	Infineon Technologies AG
07h	Texas Instrument
16h	EM Microelectronic-Marin SA

Figure 7-2: Manufacturer codes

Preliminary

7.2 Memory organization

An ISO15693 tag is separated into two blocks. An administrative block which contains the UID, AFI, DSFID and the lock page state. The user block is free for custom use. The chip manufacturer defines the amount of bytes and number of pages of each tag. As default four bytes are used for several tags.

Page address	**Byte**			
	0	**1**	**2**	**3**
3Fh	User data			
…	…			
00h	User data			
Administrative block				

Figure 7-3: Memory organization of ISO 15693

Preliminary

7.3 my-d IC (SRF55VxxP)

my-d ICs are specific ICs from Infineon. These labels show a different memory organization. Two different modes of tags are supported: plain and secure mode.

Two different cards with 320 bytes or 1k bytes EEPROM memory are available. The EEPROM memory is divided into pages.

Each tag is split into two parts: The administrative blocks (00h, 01h, 02h) and the user area. Administrative pages are read only and cannot be changed. User data is free for use. Additionally user data pages can be locked. This procedure is irreversible.

The EEPROM of SRF55V10P is organized in 128 pages addressed 00h to 7Fh. The EEPROM of SRF55V02P consists of 32 pages addressed 00h to 1Fh.

Address	**Byte number within a page**									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**		
7Fh	User data									SRF55V10P
…	…									
1Fh	User data								SRF55V02P	
…	…									
03h	User data									
02h										
01h										
00h	Serial number (UID)									

Figure 7-4: SRF55VxxP memory organization

7.3.1 UID

The UID of SRF55Vxx labels starts with 60h or E0h.

7.3.2 Security Bit

Bit 45 of the UID defines the secure mode of the SRF55Vxx. If set the tag supports security algorithm.

Bit 45	**Description**
1	Tag supports crypto security mechanism
0	Chip supports plain mode only

Figure 7-5: Security bit

Preliminary

7.4 EM 4135

The EM4135 is an ISO15693 compliant label of EM Microelectronic-Marin SA. It has eight bytes per page as the same as the my-d label. It only supports 36 pages. The administrative area holds the information of the access condition and the UID.

Address	Page							
	0	1	2	3	4	5	6	7
23h	User data							
…	…							
00h	User data							
	Administrative area							

Figure 7-6: Memory organization of EM 4135

8 ICODE

ICODE® IC data is stored in a non-volatile EEPROM. Its capacity is 512 bits organized in 16 blocks consisting 4 bytes each (1 block = 32 bits). First 3 blocks contain administrative data.

8.1 Memory organization

Page address	Byte			
	0	1	2	3
0Fh	User data			
…	…			
05h	User data			
04h	Family code identifier / User data			
03h	Special function (EAS) / User data			
02h	Write access condition			
01h	Serial number			
00h	Serial number			

Figure 8-1: ICODE® memory organization

8.2 Serial number

The serial number of a label is defined at the manufacturer process. It is stored on page 00h and page 01h. LSB is stored first.

8.3 Write access condition

Page 02h contains the write access condition for each page. Each page can be set to read only (bits are set to 0). This procedure is irreversible. Locking page 2 no further changed of the access condition can be done. Always two bits must be change at the same time. This register is implemented as OTP.

Byte 0								**Byte 1**								**Byte 2**								**Byte 3**							
MSB							LSB	MSB							LSB	MSB							LSB	MSB							LSB
1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3		2		1		0		7		6		5		4		B		A		9		8		F		E		D		C	
Special function		Write access		Serial number		Serial number		User data		...		...		...		...		...		...		...		...		...		...		User data	

Figure 8-2: Write access condition bytes

8.4 Special function (EAS), AFI

Special Functions (EAS) and Family Code/Application Identifier are additional features. For more information refer to the ICODE® manual.

8.5 User data

All other blocks are free for use and can be changed according the state of the write access conditions.

9 ICODE EPC

ICODE EPC labels data is stored in a OTP memory. Its capacity is 136 bits organized in 17 blocks consisting of 1 bytes each. All MSB of the different fields (EPC, CRC16, Destroy Code) are located at the lowest block address.

9.1 Memory organization

Page address	**Byte**
14h – 16h	Destroy Code
12h – 13h	CRC 16
00h – 11h	EPC

Figure 9-1: ICODE EPC memory organization

Preliminary

9.2 Serial number

The serial number of a label is defined within the EPC blocks.

9.3 Read Block

It is not possible to read a block with the read block 'rb' command.

9.4 Write Block

It is possible to write the EPC data (12 bytes) with the write block 'wb' command using block address 00h.

10 ICODE UID

The memory has a capacity of 192 bits and is organized in 24 blocks, consisting of 1 byte each. All MSB of the different fields (UD, UD CRC, CRC16, Destroy Code) are located at the lowest block address.

10.1 Memory organization

Page address	Access Condition	Description
21h – 23h	OTP	Destroy Code
19h - 20h	OTP	CRC16
14h – 18h	RO	UID
12h – 13h	R/W	UD CRC16
00h – 11h	R/W	User data (UD)

Figure 10-1: ICODE UID memory organization

10.2 Read Block

It is possible to read the user data (12 bytes) with the read block 'rb' command using block address 00h.

10.3 Write Block

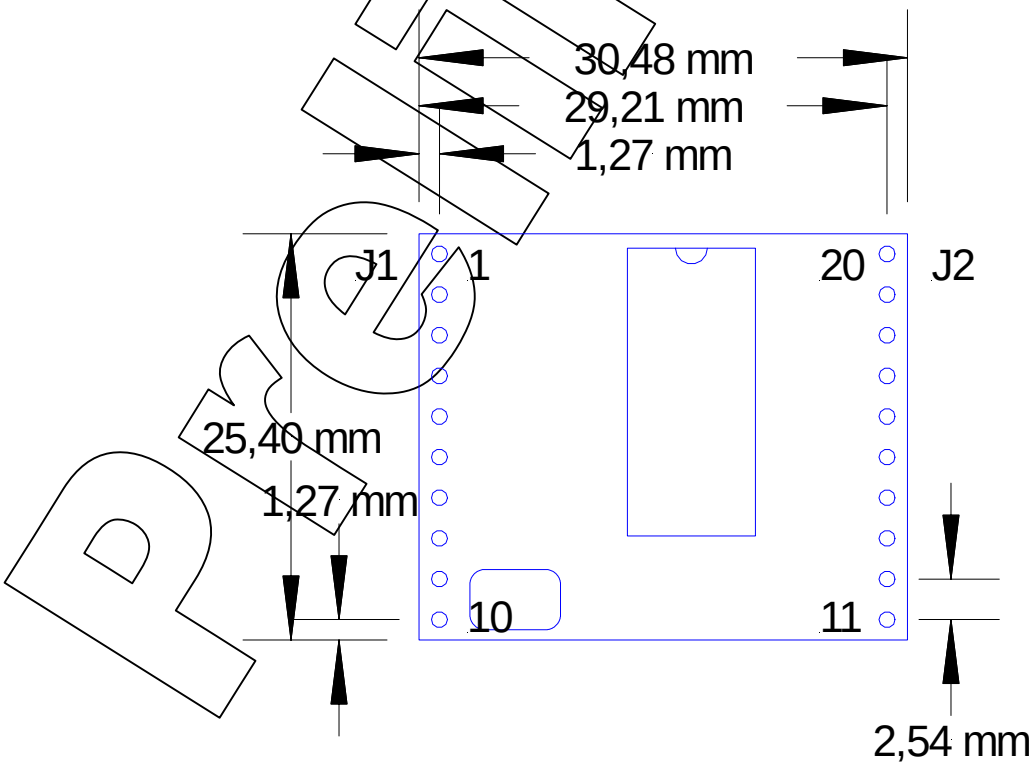
It is possible to write the UD data (12 bytes) with the write block 'wb' command using block address 00h.

Additionally it is possible to write the destroy code (3 bytes) with the write block 'wb' command using block address 01h.

Preliminary

11 Hardware

11.1 Pin out of OEM Module (Top View)



Preliminary

11.1.1 Pin out of J1

PIN	PIN Nr	Description
ARX	1	Antenna RX
ATX1	2	Antenna TX1
VDD	3	+5 V DC (4.5VDC to 5.5VDC)
GND	4	Ground
ATX2	5	Antenna TX2
TGND	6	Antenna Ground
SAM CLK	7	SAM clock
SAM IO	8	SAM IO
SAM RESET	9	SAM Reset
RFU	10	Reserved for future use

Figure 11-1: Pin out of jumper 1

11.1.2 Pin out of J2

PIN	PIN Nr	Description
VDD	20	+5 V DC (4.5VDC to 5.5VDC)
GND	19	Ground
LEDg	18	LED green (reading LED)
LEDr	17	LED red
EN	16	Enable reader, open or logic high
MCLR	15	Master clear
USER	14	User Port
DIR	13	Direction of RS 485
TX	12	TX to PC
RX	11	RX from PC

Figure 11-2: Pin out of jumper 2

Preliminary

11.1.3 Electrical characteristics of PINs

PIN	PIN Nr	Voltage	Current (max)	Description
RX TX	11 12	USART[2]	-	To RS232, RS485 or RS422 device driver
USER	14	TTL[3]	25 mA	User sets logic state
EN	16	ST[4]	25 mA	Low will disable the reader device
LEDr	17	TTL	25 mA	Logic Low, used for LED
LEDg	18	TTL	25 mA	With 330 Ω (internal serial) resistor
ARX ATX1 ATX2 TGND	1 2 5 6	(depends on antenna tuning)	200 mA_{PP}	Antenna input Antenna output Antenna output (GND) RF-Output: approx 150mW at 50 Ohms
SAM CLK	7	TTL		Clock for SAM (3.39MHz)
SAM IO	8	TTL		SAM IO for input and output
SAM RESET	9	TTL		SAM reset
RFU	10,15	-	-	Not connected
GND	4,19	GND	-	Supply Ground
VDD	3,20	+5 V DC (+4.5V DC to +5.5 VDC)	150 mA	Supply Voltage[5]
DIR	13	TTL	25 mA	RS485 direction
MCLR	15	TTL		Leave unconnected. Low will reset the register and the key management to default values. Internal pull up resistor.[5]

[2] Universal Synchronous Asynchronous Receiver Transmitter

[3] TTL buffer output / input

[4] Schmitt trigger buffer output

[5] Voltage spikes below GND at the MCLR/V_{DD} pin, including currents greater than 80mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the MCLR/V_{DD}, rather than pulling this pin directly to GND.

Preliminary

Figure 11-3: Electrical characteristics of pins

12 Software

By default, data is transmitted at 9600, n, 8, 1, no handshaking. Two protocol modes are supported. The protocol mode is configured in the reader EEPROM. As factory default, the ASCII protocol is used.

12.1 ASCII Protocol

This protocol is designed for easy handling. The commands are issued using a terminal program. Data is transmitted as ASCII hexadecimal that can be displayed on any terminal program (i.e. HyperTerminal).

Command	Data
Variable length	Variable length

Figure 12-1: ASCII protocol frame

12.2 Binary Protocol

This protocol is designed for industrial applications with synchronization and frame checking. An addressing byte for party line (master/slave, multi-drop) is also included.

The protocol usually requires a device driver. Data is transmitted in binary mode. The reader uses an internal binary watchdog timer to ensure correct framing.

STX	Station ID	Length	Data	BCC	ETX
1 byte	1 byte	1 byte	Variable length	1 byte	1 byte

Figure 12-2: Binary Frame Version 1

The binary frame version 2 is only sent to the host. It is implemented to give extended information to the host.

Version 2 must be enabled in the Protocol configuration 2 register.

STX	Station ID	Length	Flags	Data	BCC	ETX
1 byte	1 byte	1 byte	1 byte	Variable length	1 byte	1 byte

Figure 12-3: Binary Frame Version 2

Preliminary

12.2.1 STX

Start of transmission (02h)

12.2.2 Station ID

Unique ID of the station

00h: reserved for the bus master. Readers send response to this device ID.
FFh: Broadcast message. All devices will execute the command and send their response.

12.2.3 Length

Length defines the length of the data block, including the flag byte, if binary protocol version 2 is activated.

If length is set to zero, 256 data bytes are transmitted. The reader module only can send 256 data bytes, but cannot receive commands with 256 bytes.

12.2.4 Flags

The flag byte gives additional information to the host.

Bit 3 – Bit 7	Bit 1 – Bit 2	Bit 0
RFU	Leading Character Info	Error State

Error State

If cleared, the command was processed successfully.

If Error State is set, an error occurred.

Leading Character Info

Bit 1 & 2 defines how to interpret the data in the binary frame.

Bit 2	Bit 1	Description
0	0	No leading character available, all values are hexadecimal.
0	1	The data contains one leading character.
1	0	All data bytes are characters.
1	1	RFU

12.2.5 Data

This part contains the command and the data. The command values are the same as in ASCII protocol mode (‘x’, ‘s’, …) whereas data is transmitted in binary mode.

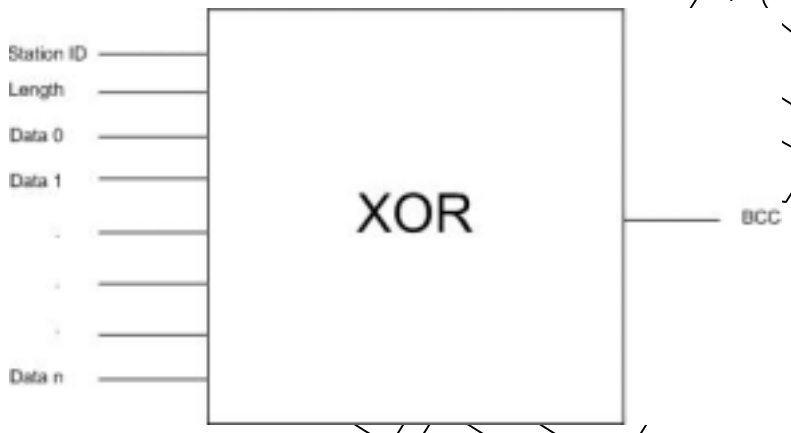
The length of the command block depends on the instruction.

Preliminary

12.2.6 Block Check Character (BCC)

The BCC is used to detect transmission errors. The BCC is calculated XOR-ing each byte of the transmission frame excluding the STX/BCC and ETX characters. The flags are part of the data.

$$BCC = (StatID)\ XOR\ (Length)\ XOR\ (Command / Data_0)\ XOR \ldots XOR\ (Command / Data_N)$$



12.2.7 ETX

End of transmission. (03h)

12.2.8 Remarks

If the reader device receives an invalid instruction frame (i.e. wrong BCC) or the requested station ID does not match the internal ID of the reader, the command is not executed. The reader waits for the next valid frame.

The automatic binary time-out (see protocol configuration register) is used to detect incomplete binary frames.

12.2.9 Examples:

02h	64h	01h	78h	1Dh	03h
STX	Station ID	Length	'x'	BCC	ETX

This instruction frame will reset the reader module with the station ID 64h.

Preliminary

12.3 Register Set

The reader has several system flags used for customization purposes. The flags are stored in its non-volatile EEPROM. The reader accepts changes to these settings only during the start-up phase. Clearing all RFU bits is recommended in order to guarantee compatibility with future releases.

The reader can store up to 32 authentication keys internally to login standard Mifare cards. An additional 32 keys can be stored for DESFire authentication. All keys are read only and cannot be accessed via the interface lines.

Preliminary

12.3.1 EEPROM memory organization

Register	Description
00h … 04h	Unique device ID; read only
05h … 09h	Administrative data; read only
0Ah	Station ID
0Bh	Protocol configuration
0Ch	Baud rate
0Dh	Command Guard Time
0Eh	Operation Mode
0Fh	Single shot time-out value
10h	Internal use / Do not change
11h	Internal use / Do not change
12h	Internal use / Do not change
13h	Protocol configuration 2
14h	Reset Off Time
15h	Reset Recovery Time
16h	Application Family Identifier
17h	ISO 14443A Selection Time-out
18h	ISO 14443B Selection Time-out
19h	SR176 Selection Time-out
1Ah	ISO 15693 Selection Time-out
1Bh	Protocol configuration 3
1Ch	Page Start
1Dh	Internal use / Do not change
1Eh	Internal use / Do not change
1Fh	Page number
20h - 7Fh	RFU
80h … EFh	User data

Figure 12-4: EEPROM memory

12.3.2 Unique device ID (00h – 04h)

The unique device ID identifies a reader module. It is factory programmed and cannot be changed.

Preliminary

12.3.3 Station ID (0Ah)

The station ID is used in binary mode to address a device in party line set up. The station ID can range from 01h to FEh and can be set freely. The value 00h is reserved for the bus master. All readers send their response to this device.

The broadcast message (FFh) forces all readers to response to the command.

Default value is 01h.

12.3.4 Protocol configuration (0Bh)

The protocol configuration register (PCON) specifies general behavior of the reader device.

Default value is 41h.

Protocol configuration register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Extend-ed ID	Extend-ed Protocol	Single-shot	LED	New serial mode	Multitag	Protocol	Auto-start

Figure 12-5: Protocol configuration register

12.3.4.1 Auto start (default 1)

If set, the reader device will start up in continuous read mode automatically.

This is only valid in ASCII mode.

12.3.4.2 Protocol (default 0)

If Protocol is set to ‘1’, then the reader uses binary protocol mode. Refer to binary protocol for further information on the binary protocol format.

Default setting = ASCII protocol (0).

12.3.4.3 Multitag (default 0)

The Multitag flag will enable multi-tag recognition in continuous read mode. All tags are detected and displayed. Due to the more complex search algorithm, the continuous read command decreases its detection speed.

12.3.4.4 New Serial Mode (default 0)

If New Serial Mode is set to ‘1’, new serial mode is enabled. The leading character ‘M’ is added to the serial number of ISO 14443 type A tags, a leading 'Z' character is added to ISO 14443 type B tags and a leading 'S' character for SR176 tags.

12.3.4.5 LED (default 0)

If set the reader suppresses any LED activity. The user manages the state of the LEDs.

Preliminary

12.3.4.6 Single Shot (default 0)

If Single Shot is set, the reader displays the serial number of a tag in continuous read mode once within a specified time-out. The time-out is defined at EEPROM register 0Fh.

The delay time can be adjusted stepwise in 100ms steps. 00h indicates no delay and FFh indicates infinite delay.

12.3.4.7 Extended Protocol (default 1)

If Extended Protocol is set, the transfer data telegram command supports ISO14443-4 and automatically process the WTX and chaining for smaller frames.

If sending ISO 14443-3 commands this flag has to be switched off.

The transfer data telegram command is only supported in normal mode, not in transmit / receive mode.

Preliminary

12.3.4.8 Extend ID (default 0)

If Extended ID is set, the reader extends the serial number of tags with additional bytes.

ISO 14443 A tags (5/8/11 bytes transmitted)

Tag type	Serial number
1 byte	4 / 7 / 10 bytes

Figure 12-6: ISO 14443 A Extended Serial number

The tag type byte indicates the type of cascade level.

Tag type	Description
00h	Cascade level 1 transponder
01h	Cascade level 2 transponder
02h	Cascade level 3 transponder

Figure 12-7: ISO 14443 A tag type

ISO 14443 B tags (12 bytes transmitted)

Serial number	Application data	Protocol info	CID
4 bytes	4 bytes	3 bytes	1 byte

Figure 12-8: ISO 14443 B Extended Serial number

For detailed description of Application Data, Protocol Info and CID, refer to the ISO 14443 documentation [1].

Preliminary

12.3.5 BAUD, Baud rate control register (0Ch)

The baud rate register defines the communication speed of the reader device.

Default value is 00h.

Baud rate register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	RFU	RFU	RFU	BS2	BS1	BS0

Figure 12-9: Baud rate register

This register defines the baud rate of the device.

BS2	**BS1**	**BS0**	**Baud rate**
0	0	0	9600 baud (default)
0	0	1	19200 baud
0	1	0	38400 baud
0	1	1	57600 baud
1	0	0	115200 baud
1	0	1	230400 baud (depends on the used interface chip)
1	1	0	460800 baud (depends on the used interface chip)

Figure 12-10: Baud rate settings

With the high baud rates (230400 and 460800 baud), proper operation depends on the interface chip used. Please note that some of the interface chips available do not support these high baud rates.

Preliminary

The following table describes the exact baud rates used by the reader.

Baud rate	Exact baud rate	Difference
9600 baud	9603 baud	0.03 %
19200 baud	19207 baud	0.04 %
38400 baud	38305 baud	-0.25 %
57600 baud	57458 baud	-0.25 %
115200 baud	114915 baud	-0.25 %
230400 baud	233793 baud	1.47 %
460800 baud	452000 baud	-1.91 %

Figure 12-11: Exact baud rates

The following table describes the communication settings

Description
8 data bits
No parity bit
1 stop bit
No flow control

Figure 12-12: Communication settings

12.3.5.1 CF Card Version

The Baud rate of the CF Card version is limited to 115200 baud. 230400 and 460800 are not supported.

12.3.6 Command Guard Time (0Dh)

The Command Guard Time is used to ensure that commands are not sent to fast consecutively. Following commands are sent after the guard time is elapsed. One time slice is around 37,8us. The longest timeout value is 9,6ms (FFh).

The default value is 20h (1,2ms).

Preliminary

12.3.7 OPMODE, operating mode register (0Eh)

The operation mode register defines which tag types the reader supports. This register enables fast tag recognition because only defined tag types are requested.

Operation mode register							
Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
RFU	ICODE UID	ICODE EPC	ISO 15693	ICODE	SR176	ISO 14443B	ISO 14443A

Figure 12-13: Operation mode register

12.3.8 Single Shot Time-out (0Fh)

The time-out value defines the delay time between two responses of the reader. It only has effect in continuous read mode. To enable the time-out, the single shot flag has to be set. See the protocol configuration register above. One time-out slice is around 100ms. Exact timing depends on the protocol used.

Value 00h indicates no delay time.

Default value is 0Ah (1 second).

12.3.9 Protocol configuration 2 (13h)

The protocol configuration register 2 (PCON2) further specifies the general behavior of the reader device.

Default value is 00h.

Protocol configuration 2 register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Disable ISO 14443 -4 Error Handling	Enable ISO 14443B Anti-collision	Reset Recovery Time Multiplier		Noisy Environ-ment	Enable binary frame v2	Disable start-up message	Disable multi-tag reset

Figure 12-14: Protocol configuration register

12.3.9.1 Disable multi-tag reset (default 0)

If set, the reader does not reset before the multi-tag list and multi-select command have been performed.

12.3.9.2 Disable start-up message (default 0)

If Disable start-up message is set, the reader suppresses the start-up message in ASCII mode. This flag is ignored in binary protocol mode.

12.3.9.3 Enable binary frame v2 (default 0)

If Enable binary frame v2 is set, the reader sends version 2 binary frames.

The get station ID command always sends version 1 binary frames!

12.3.9.4 Noisy Environment (default 0)

If Noisy Environment is set, the continuous read mode can only be aborted with the '.' character. When working in a noisy environment, the probability for a reception of an arbitrary/stochastic signal is quite high. This implies a high probability of an unintentional command execution. To reduce this probability, only one character (out of 255) is chosen ('.') to be interpreted as the continuous read stop command.

12.3.9.5 Reset Recovery Time Multiplier (default 0)

Multiplies the Reset Recovery Time, including the recovery time of the field reset command.

Reset Recovery Time Multiplier	Reset Recovery Time
0	1x
1	2x
2	3x
3	4x

Figure 12-15: Reset Recovery Time Multiplier

12.3.9.6 Enable ISO14443 B Anti-collision (default 0)

If set, the anti-collision algorithm for ISO 14443 B tags is enabled.

12.3.9.7 Disable ISO 14443-4 Error Handling (default 0)

If Disable ISO 14443-4 Error Handling is set, ISO14443-4 Error Handling is disabled. The error handling always uses the TMR time-out.

12.3.10 Reset Off Time (14h)

The Reset Off Time register represents the field off time in ms.

This register is used for the select, continuous read and multi-tag commands.

Default value is 0Ah.

12.3.11 Reset Recovery Time (15h)

The Reset Recovery Time register represents the recovery time in ms after the field is turned on.

This register is used for the select, continuous read and multi-tag commands.

Default value is 25h.

12.3.12 Application Family Identifier (16h)

The AFI (Application Family Identifier) is only supported for ISO14443B and ISO15693 tags. If the set value is different from 00h, the AFI is used. Only transponders with an identical AFI will answer to the reader.

Default value is 00h.

12.3.13 Selection Time-out ISO 14443A (17h)

The Selection Time-out represents the reader card communication time-out for the select, high speed select, continuous read, multilist, multiselect and Mifare® login command with ISO 14443A tags. Use low values for a better reaction time between the card and the reader. One time slice is around 300us.

The default value is 10h.

12.3.14 Selection Time-out ISO 14443B (18h)

The Selection Time-out represents the reader card communication time-out for the select, high speed select, continuous read, multilist and multiselect commands with ISO 14443B tags. For a better reaction time, use low values. One time slice is around 300µs.

The default value is 50h.

12.3.15 Selection Time-out SR176 (19h)

The Selection Time-out represents the reader card communication time-out for the select, continuous read, multilist and multiselect command with SR176 tags. For a better reaction time, use low values. One time slice is around 300µs.

The default value is 10h.

12.3.16 Selection Time-out ISO 15693 (1Ah)

The Selection Time-out represents the reader card communication time-out for the select, high speed select, continuous read, multilist, multiselect and Mifare® login command with ISO 15693 tags. Use low values for a better reaction time between the card and the reader. One time slice is around 300us.

The default value is 20h.

Preliminary

12.3.17 Protocol configuration 3 (1Bh)

The protocol configuration register 3 (PCON3) further specifies the general behavior of the reader device.

Default value is 00h.

Protocol configuration 3 register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	ReqA Extended ID	Internal use / do not change			Page Read	RFU	Disable automatic ISO 14443-4 timeouts

Figure 12-16: Protocol configuration register

12.3.17.1 Disable automatic ISO 14443-4 timeouts (default 0)

If Disable automatic ISO 14443-4 timeouts is set the automatic ISO 14443-4 timeouts are disabled. The timeouts specified with TMR registers are used.

12.3.17.2 Page read (default 0)

If set the continuous read mode retrieves the content of the tag instead of the serial number. The register Page Start (1Ch) defines the start block and the Page Number (1Fh) defines the number of blocks to be read.

12.3.17.3 ReqA Extended ID (default 0)

If set the Extended ID information for ISO14443 A tags replaces the cascade level information (1 byte) with Request A answer (2 bytes).

12.3.18 User data (80h - EFh)

These registers are for free use.

Preliminary

12.4 Instruction Set

Following table describes all the commands of the reader device. Each command returns an answer to the host. Exceptions are mentioned explicitly. The green LED acknowledges a successfully executed command. The red LED indicates an error.

Preliminary

12.4.1 Common Commands Overview

Command	Description
'!'	Test continuous read / Check KTT upload status
'c'	Continuous read
'.'	Abort continuous read, refer to continuous read
'dg' / 'dn' / 'dr'	Set LED
'ds'	DES encryption / decryption of data
'f'	DESFire command set
'g'	Get ID
'h'	High speed select
'k'	Lock block
'm'	MultiTag select / tag list
'o+a' / 'o+b' / 'o+d' / 'o+e' / 'o+i' / 'o+s' / 'o+v'	Include tag type
'o-a' / 'o-b' / 'o-d' / 'o-e' / 'o-i' / 'o-s' / 'o-v'	Exclude tag type
'oa' / 'ob' / 'od' / 'oe' / 'oi' / 'ot' / 'os' / 'ov'	Set tag type
'of'	Set configuration flags
'og'	Set configuration register
'poff' / 'pon'	Antenna power off/on
'pr' / 'pw'	Read / write user port
'q'	Quiet
'ra'	Resend last answer
'rp'	Read EEPROM register
'r' / 'rb'	Read block
's'	Select
'v'	Get version
'w' / 'wb'	Write block
'wp'	Write EEPROM register

Figure 12-17: Command overview (Part 1)

Confidential

Command	Description
'x'	Reset
'y'	Field reset
ISO 14443 Type A (Mifare) only commands	
'+'	Increment value block (credit)
'-'	Decrement value block (debit)
'='	Copy value block (backup)
'l'	Login (authenticate tag)
'rv'	Read value block
'wv'	Write value block
Key Management	
'ar'	Authenticate to reader
'ia'	Get key access rights
'it'	Get key status
'rt'	Reset key table
'ua'	Update key access rights
'uc'	Change key type
'uk'	Update key
my-d Secure commands	
'!'	Check KTT upload status / Test continuous read
'*'	Abort KTT upload
'as'	Authenticate to sector
'ik'	Issue transponder key
'ut'	Prepare for KTT
'z'	my-d command

Figure 12-18: Command overview (Part 2)

Preliminary

12.4.2 Error Codes

Following figure shows an overview of all error messages of the reader device.

Error Code	Description
‘?’	Unknown command
'C'	Collision or CRC/MAC Error
‘F’	General failure
‘I’	Invalid value format, specified block does not match the value format
‘N’	No tag in the field
'O'	Operation mode failure or file not selected
‘R’	Command parameter out of range
'X'	Authentication failed

Figure 12-19: Error codes

Preliminary

12.4.3 Common commands

12.4.3.1 Test Continuous Read / Check KTT Upload Status

This command tests the state of the continuous read command and the state of the Prepare for KTT 'ut' command.

The test continuous read command is only valid in ASCII mode.

Command

Command	Data
'!'	None

Answer

Answer	Description
'!'	Continuous read mode is active.
00h	Keys from KTT successfully uploaded
01h	Error during key upload detected, upload aborted
02h	No KTT found, other tag was detected
FFh	Prepare for KTT is in awareness mode
'F'	Continuous read and Prepare for KTT is not active.
no response	Key uploading is in progress

12.4.3.2 Continuous Read

The reader device reads and displays serial numbers continuously while one or more tags remain in the field. This command stops if any character is sent to the reader module. The reader module returns the character ‘S’ (53h).

The reader supports different tag types at the same time. To increase the reading performance switch to a single tag mode. If more than one tag of the same type should be detected at the same time, the Multitag flag must be activated. The response data length depends on the tag type.

Command

Command	Data
'c'	None

Preliminary

Answer

Answer	Description
Data	Serial number (n bytes)
'N'	Error: No Tag in the field (only binary protocol)

12.4.3.2.1 Multitag continuous read mode

If the Multitag flag is set in the Protocol Configuration (PCON) register the reader reads multiple tags continuously.

12.4.3.2.2 Auto start

The continuous read mode is started automatically in ASCII mode. The auto start flag must be set in the PCON register.

12.4.3.2.3 Noisy Environment

If the Noisy Environment flag is set, the continuous read mode can only be aborted with the '.' character.

This is only valid in ASCII mode.

12.4.3.2.4 Binary mode

This command is fully supported in binary protocol mode except the test continuous read command and the noisy environment flag.

Do not use this command on bus system environment in binary mode, because the continuous read mode will take possession of the bus system.

12.4.3.2.5 Simple access control applications

Serial numbers are always sent plain. Data encryption is activated after a successful login.

For simple access control applications the use read-only blocks for the identification of the tag is recommended.

Reading any block (even the manufacturer block) of the transponder will increase your security.

Preliminary

12.4.3.3 Set LED

This command controls the LED activity. If the LED flag is set, the automatic LED function is switched off. The user can set the state of the LED manually.

Command

Command	Data
'dg'	None
'dr'	None
'dn'	None

Answer

Answer	Description
'DG' 'DR' 'DN'	String of LED state

Example

Command	Answer	Description
'dg'	DG	Switch on LED green, LED red off
'dr'	DR	Switch on LED red, LED green off
'dn'	DN	Switch off both LEDs

Preliminary

12.4.3.4 DES encryption / decryption of data

This command returns 8 bytes of encrypted / decrypted data.

Command

Command	Data
'ds'	Options (1 byte) Key (8/16 bytes) / Key Number (1 byte) Data (8 byte)

Answer

Answer	Description
Data	Encrypted / Decrypted data (8 bytes)

Option byte

Option byte							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	RFU	RFU	RFU	Encode	Key Length	Key Index

Key Index

If the Key Index is set, the command only needs the key number (1 byte) instead of the key (8/16 bytes).

The key number corresponds to the key number used in the key management.

Key Length

If the Key Length is set, the command uses the TDES algorithm with 16-byte key.

If cleared, the command uses the DES algorithm with 8-byte key.

If key index is used the key length flag is valid.

Encode

Setting this flag encodes the data.

Clearing this flag decodes the data.

Preliminary

12.4.3.5 Get ID

This command returns the station ID of the reader device. The answer is time slotted to enable the detection of all devices in party line mode.

The station ID has only effect in binary mode.

Command

Command	Data
'g'	None

Answer

Answer	Description
Data	Station ID of the reader device (1 byte)

Preliminary

12.4.3.5.1 Time slotted answer

In party line mode, more than one reader can be used simultaneously. The time slotted answer allows separating in time the answers from all connected devices. The station ID is used to determine the correct time slot.

The reader supports up to 254 unique time slots. The following formula calculates the duration of one time slot (only one baud rate is supported per party line):

$$T_0[s] = \frac{10}{Baudrate} * 6$$

Figure 12-20: Time slot formula

The following figure shows the timing diagram of time slotted answers.

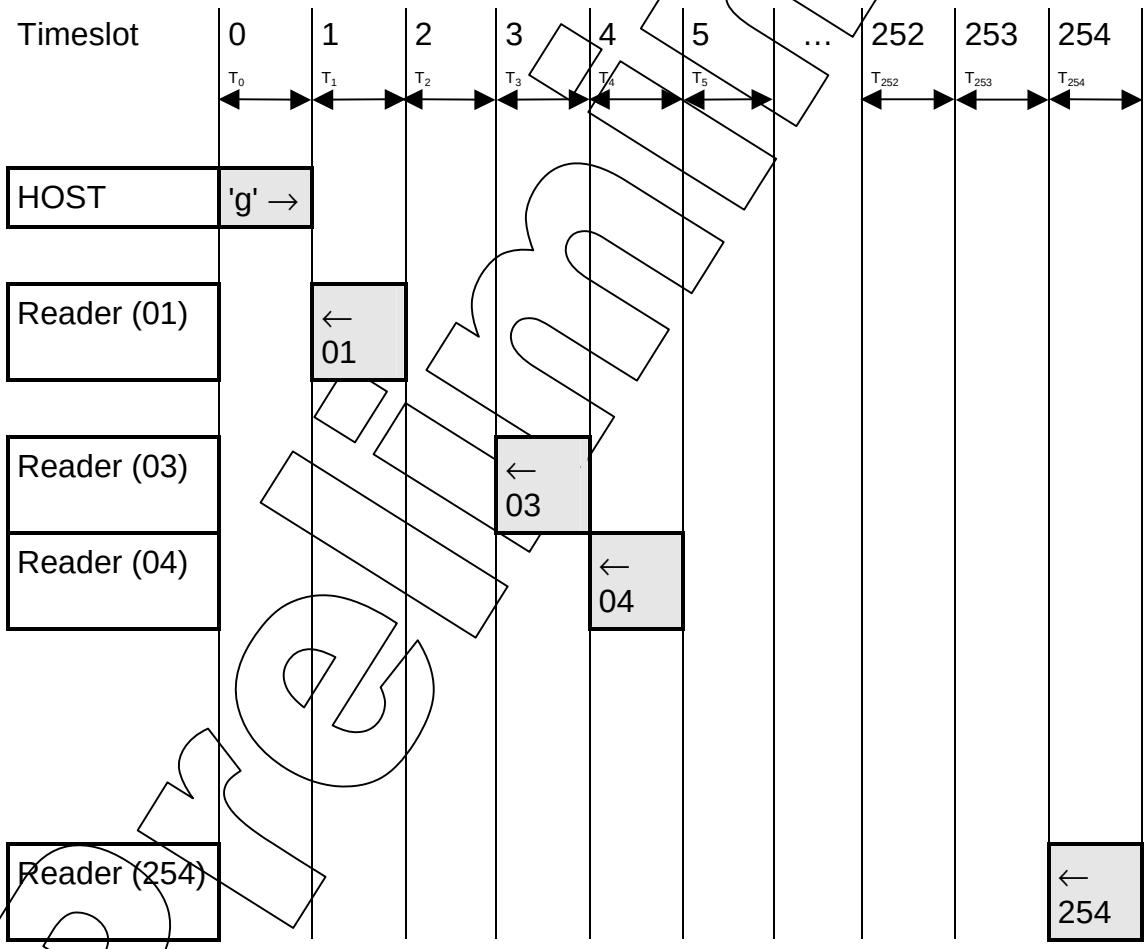


Figure 12-21: Timing diagram of time slotted answers

Preliminary

12.4.3.5.2 Binary Protocol Version 2

This command never sends version 2 binary frames.

12.4.3.6 High speed select

This command selects a card in the antenna field (according to the selection criteria) or prepares a multiselect command, switches to high baud rates and enables 256-byte frames. If execution is successful, the command returns the UID of the selected card and the used baud rate. The reader automatically detects the maximum frame size of the card. The reader also tries to communicate to the transponder with the specified baud rate. If no communication is possible, the reader will automatically decrease the speed to the next lower value.

This command can also force the reader to the communication speed and frame size of the tag to the specified values. This is only needed if the high speed select is done manually with the transfer command.

Command

Command	Data
'h'	Option byte (1 byte) 00h … select a single card with 106kBaud 02h … select a single card with 212kBaud 04h … select a single card with 424kBaud 08h … select a single card with 848kBaud 10h … prepare next multiselect for 106kbaud 12h … prepare next multiselect for 212kbaud 14h … prepare next multiselect for 424kbaud 18h … prepare next multiselect for 848kbaud 20h … forces reader to 106kBaud 22h … forces reader to 212kBaud 24h … forces reader to 424kBaud 28h … forces reader to 848kBaud 30h – 38h … force tag frame size

Preliminary

Answer

Answer	Description
Data (n bytes) + frame size and baud rate (1byte)	Serial number + frame size used and baud rate
'F'	Error: General failure
‘N’	Error: No Tag in the field

Examples

High speed select

Command	Description
h08	1234567890ABCD84 Select the card with UID 1234567890SABCD. The card supports a 256-byte frame size and 424kBaud on the air interface.

High speed multiselect

Command	Description
h18 m1234567890ABCD<CR>	Prepare next multiselect for 848kBd 1234567890ABCD84 Select the card with UID 1234567890SABCD. The card supports a 256-byte frame size and 424kBaud on the air interface.

Preliminary

12.4.3.6.1 Answer from 0xh and 1xh

The lower nibble contains the baud rate used for the air interface.

Baud Rate	Description
x0	106kBaud
x2	212kBaud
x4	424kBaud
x8	848kBaud

Figure 12-22: Baud Rate values

The higher nibble contains the frame size used for the air interface.

Frame Size	Description
0x	16 Bytes
1x	24 Bytes
2x	32 Bytes
3x	40 Bytes
4x	48 Bytes
5x	64 Bytes
6x	96 Bytes
7x	128 Bytes
8x	256 Bytes

Figure 12-23: Frame Size

12.4.3.6.2 Answer from 2xh and 3xh

The option byte is returned as the answer.

12.4.3.6.3 Select a single tag

No previous continuous read is required. The command executes an automatic field reset.

12.4.3.6.4 Extended ID

See above for more information on Extended ID.

The RATS answer is inserted between the serial number and baud rate / frame size byte for ISO14443 A tags.

Preliminary

12.4.3.6.5 Multiple tags

This command with parameter 1xh prepares the next multiselect command as a high-speed select. Any other command will disable the preparation.

12.4.3.6.6 RATS Guard Time SFGT

A high-speed select with parameters 0xh and 1xh automatically waits the SFGT guard time received from the tag before sending the PPS command.

12.4.3.7 Lock block

This command locks a block permanently. Only SR176 and ISO 15693 tags are supported.

Command

Command	Data
'k'	Block address (1 byte)

Answer

Answer	Description
data	'K' + page address
'F'	Error: Lock failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure (only SR176 and ISO 15693 tags are supported)
'X'	Error: Block already locked

Example

Command	Description
k05	K05 Lock block 05.

12.4.3.7.1 Operation mode failure 'O'

The presented tag is not a SR176 or a ISO 15693 tag.

Preliminary

12.4.3.7.2 Apply settings

After locking a block permanently, the tag needs to be selected for the settings to apply.

12.4.3.8 Multi-Tag Selection / List

This command detects several tags at the same time. It replaces the fast select command ('s') in multiple tag surroundings. The Multi-Tag List command lists all tags with their serial numbers. Use the Multi-Tag Select command to select a single tag. Each tag has to be selected separately.

Command

Command	**Data**
'm'	Serial number (n bytes) <CR> (1 byte)

Answer

Answer	**Description**
Data	serial number
'N'	Error: No Tag in the field

Example

Command	**Description**
m<CR>	04E9E700000000 → first card 34030F07 → second card 02 → number of detected tags
m04E9E700000000<CR>	Select card with its serial number

12.4.3.8.1 Multi-tag list

Sending a <CR> as the first parameter, the reader returns a list of all tags present in the antenna field. In the end the total number of tags detected is returned.

Preliminary

12.4.3.8.2 Reading distance

Each card needs a specific amount of power. The reader always provides the same power level. Therefore, the reading distance will decrease if more tags are present. Basically, the reading distance depends on the tag, the antenna and the tuning of the antenna.

12.4.3.8.3 Multi-tag select

Using the serial number with <CR> as parameter, the corresponding tag will be selected. High-level interactions can be performed addressing only this card. All other tags remain silent.

12.4.3.8.4 Multi-tag reset

The antenna field reset can be deactivated with the Protocol configuration 2 register.

By suppressing the antenna field reset, it is possible to detect only new tags in the antenna field.

12.4.3.8.5 Maximum number of tags

The maximum number of tags in the antenna field is limited to 64 and by the physical characteristics of the antenna.

Preliminary

12.4.3.9 Include tag type

This command includes a specific tag type to those addressed by the reader device.

Command

Command	Data
‘o+’	Tag type (1 byte)

Answer

Answer	Description
'O+' + tag type (1 byte)	Command code + String of tag type

Tag type character

Refer to Set tag type.

Example

Command	Description
o+a	Include ISO14443-A to the tag types addressed by the reader device.

Preliminary

12.4.3.10 Exclude tag type

This command excludes a specific tag type from being addressed by the reader device.

Command

Command	Data
‘o-’	Tag type (1 byte)

Answer

Answer	Description
'O-' + tag type (1 byte)	Command code + String of tag type

Tag type character

Refer to Set tag type.

Example

Command	Description
o-a	Exclude ISO14443-A from the tag types addressed by the reader device.

Preliminary

12.4.3.11 Set tag type

This command sets up the reader for a specific tag type. The continuous read function will speed up because only this type of tag is addressed. After a reset, the reader starts as defined in its start-up configuration.

Command

Command	Data
'o'	ISO type (1 byte) 'a' … ISO 14443 Type A 'b' … ISO 14443 Type B 'd' … ICODE UID 'e' … ICODE EPC 'i' … ICODE 's' … SR176 't' … activate all tags 'v' ... ISO 15693

Answer

Answer	Description
'OA' 'OB' 'OD' 'OE' 'OI' 'OS' 'OT' 'OV'	String of tag type

Example

Command	Description
oa	Sets the reader device to address ISO14443-A type tags.

preliminary

12.4.3.12 Set Configuration Flags

This command allows setting some configuration flags just in time; no reset is needed. The values are not stored in the EEPROM; therefore the changed values are not available after a reset.

Command

Command	**Data**
of	flag type (1 byte) data (1 byte)

Answer

Answer	**Description**
Data (1 byte)	Current state of changed flag.
'R'	Error: Out of range

Example

Command	**Description**
of0101	Answer: 01 Enables the New Serial Mode flag.

Preliminary

Flag Types

The following table shows the Flag Type with its corresponding flag from the specified Protocol Configuration Register.

Flag Type	Corresponding Flag	Protocol Configuration Register	Valid values
00h	Multitag	1	00 / 01
01h	New Serial Mode	1	00 / 01
02h	LED	1	00 / 01
03h	Single Shot	1	00 / 01
04h	Extended Protocol	1	00 / 01
05h	Extended ID	1	00 / 01
06h	Disable Multitag Reset	2	00 / 01
07h	Noisy Environment	2	00 / 01
08h	Reset Recovery Time Multiplier	2	00 … 03
09h	Enable ISO14443 B Anti-collision	2	00 / 01
0Ah	Disable ISO14443-4 Error Handling	2	00 / 01
0Bh	Disable automatic ISO14443-4 timeouts	3	00 / 01
0Dh	Page Read	3	00 / 01
11h	ReqA Extended ID	3	00 / 01

Figure 12-24: Flag Type with corresponding flag

12.4.3.12.1 Out of range failure 'R'

The entered flag type is out of range.

Preliminary

12.4.3.13 Set Configuration Register

This command allows setting some configuration registers just in time; no reset is needed. The values are not stored in the EEPROM; therefore the changed values are not available after a reset.

Command

Command	Data
og	Register type (1 byte) data (1 byte)

Answer

Answer	Description
Data (1 byte)	Current state of changed register.
'R'	Error: Out of range

Example

Command	Description
og0450	Answer: 50 Sets the Reset Recovery Time to 50h.

Preliminary

Register Types

The following table shows the Register Type with its corresponding register.

Register Type	Corresponding Register
00h	Single shot time-out value
01h	Internal use / Do not change
02h	Internal use / Do not change
03h	Reset Off Time
04h	Reset Recovery Time
05h	ISO 14443A Selection Time-out
06h	ISO 14443B Selection Time-out
07h	SR176 Selection Time-out
08h	AFI
0Ch	Page Read Start
0Dh	Page Read Number
0Eh	Command Guard Time

Figure 12-25: Register Type with corresponding register

12.4.3.13.1 Out of range failure 'R'

The entered register type is out of range.

Preliminary

12.4.3.14 Antenna power on/off

This command controls the antenna power. It can be used to decrease the power consumption of the reader.

Command

Command	Data
'pon'	Switch reader on
'poff'	Put reader in standby mode

Answer

Answer	Description
'P'	Positive acknowledge

Example

Command	Description
poff	Put reader in standby mode

12.4.3.14.1 Power off

The reader enters standby mode. Power consumption is decreased. All tags in the antenna field are powered off and reset. Standby mode is only entered manually.

To switch off the whole unit, pin 16 (Enable) has to be set to logic low.

12.4.3.14.2 Power on

The reader leaves standby mode and is ready for the next command. Sending a tag command (i.e. select, continuous read) the reader is powered up.

Preliminary

12.4.3.15 Read/Write user port

This command sets or reads the state of the user port (pin 14) of the OEM reader device. The port is set either as output or as input.

Command

Command	Data
'pr'	None
'pw'	State of user port (1 Byte)

Answer

Answer	Description
Data	State of user port (1 Byte)
'C'	Error: Error correction fails
'F'	Error: Transmission Error / No answer received

Example

Command	Description
pr	Reads user port
pw01	Sets user port state to high

12.4.3.15.1 Read port

The port read command returns the current state of the USER port.

Port state	Description
00h	USER port is low
01h	USER port is high

Figure 12-26: Read USER port return values

Preliminary

12.4.3.15.2 Write port

If user port is used as an output, a 1kΩ resistor has to be integrated into the wire. Otherwise the reader device can be damaged.

Port state	Description
00h	Sets USER port to low
01h	Sets USER port to high
02h – 7Fh	RFU
80h - FFh	Sends a serial data frame and checks the received frame

Figure 12-27: Write User port settings

Sending a Data Frame

If the highest bit (MSB) is set in the State of the User Port, the command sends a serial data frame out the USER port.

The frame includes a start bit, 8 data bits, parity bit and a stop bit.

Transmit Frame	Description
Low	Start bit
Low	RFU
Data Bit 6	State of the User Port Bit 6
Data Bit 5	State of the User Port Bit 5
Data Bit 4	State of the User Port Bit 4
Data Bit 3	State of the User Port Bit 3
Data Bit 2	State of the User Port Bit 2
Data Bit 1	State of the User Port Bit 1
Data Bit 0	State of the User Port Bit 0
Parity Bit	Even Parity Bit
High	Stop Bit

Figure 12-28: Sending Serial Data Frame

After 2ms Guard Time the answer should be received on the User Port otherwise an error is returned.

Preliminary

Receive Frame	Description
Low	Start bit
Error Bit	If set, an error was detected.
Data Bit 6	State of the User Port Bit 6
Data Bit 5	State of the User Port Bit 5
Data Bit 4	State of the User Port Bit 4
Data Bit 3	State of the User Port Bit 3
Data Bit 2	State of the User Port Bit 2
Data Bit 1	State of the User Port Bit 1
Data Bit 0	State of the User Port Bit 0
Parity Bit	Even Parity Bit
High	Stop Bit

Figure 12-29: Receiving Serial Data Frame

If the Error bit is set or the Parity Bit is not correct, the Write User Port command returns an error code.

12.4.3.16 Quiet

This command sets a selected tag into halt state. Only ISO14443 A+B and SR176 tags are supported.

Command

Command	Data
'q'	None

Answer

Answer	Description
'Q'	Halt state successfully set.
'N'	Error: No Tag in the field

Preliminary

12.4.3.16.1 ISO 14443 Type A

With ISO14443 Type A tags, the Quiet command always answers with 'Q' because the halt command does not send any acknowledge.

12.4.3.16.2 ISO 14443 Type B

Some ISO14443 Type B tags do not support this command or do not respond. ‘Quiet’ is an ISO 14443-4 command, so it will work only if the ‘Deselect’ command is supported by the corresponding transponder.

12.4.3.16.3 SR176

With SR176 tags the Quiet command always answer with 'Q' because the completion command does not send any acknowledge.

12.4.3.17 Resend Last Answer

This command resends the last answer from the internal serial buffer of the reader.

Command

Command	**Data**
'ra'	Resend last answer

Preliminary

12.4.3.18 Read block

This command reads a data block on a card. The size of the returned data depends on the tag used. The block address range depends on the tag as well.

Command

Command	Data
'r'	Block address (1 byte), valid range 00h – 40h
'rb'	Block address (1 byte)

Answer

Answer	Description
Data	data block (depends on tag type)
'F'	Error: read failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure
'R'	Error: Out of range

Example

Command	Description
rb05	Reads block 05.

12.4.3.18.1 Read failure 'F'

This error is returned if either the reader receives bad data or the block address exceeds the block address range of the sector.

12.4.3.18.2 No tag in field 'N'

The tag does not respond. There is either no tag present or addressed.

12.4.3.18.3 Operation mode failure 'O'

The presented tag is not ISO14443 type A, SR 176, ICode, ICode-UID and ISO 15693 compliant.

For ISO 14443 type A only Mifare tags are supported.

Preliminary

12.4.3.18.4 Out of range failure 'R'

The block address of the 'r' command is higher than 40h.

The block address of the 'r' command conflicts with other commands, therefore the block address has to be limited to 40h.

Use the 'rb' command instead.

12.4.3.19 Read reader EEPROM

This command reads the internal reader EEPROM. It contains all start-up parameters and the device ID. Changes in the start-up settings will only go into effect after a reset of the device.

Command

Command	**Data**
'rp'	EEPROM address (1 byte) 00h … EFh

Answer

Answer	**Description**
Data	EEPROM data (1 byte)
'R'	Error: Out of range failure

Example

Command	**Description**
rp0B	Reads protocol configuration register.

12.4.3.19.1 Out of range failure 'R'

The entered EEPROM address is not valid.

Preliminary

12.4.3.20 Select

This command selects a single card in the antenna field. It can only be used in single tag mode. If successfully executed, the command returns the UID of the selected card. The reader detects the length of the UID automatically.

Command

Command	Data
's'	None

Answer

Answer	Description
Data	serial number
'N'	Error: No Tag in the field

Example

Command	Description
s	1234567890ABCD Select the card with UID 1234567890SABCD.

12.4.3.20.1 Select a single tag

No previous continuous read is required. The command executes an automatic field reset.

12.4.3.20.2 Extended ID

See above for more information on Extended ID.

12.4.3.20.3 Multiple tags

This command is designed for fast access of a single tag in the field. If multiple cards are used the 'm' instruction has to be used instead.

Preliminary

12.4.3.21 Get Version

This command returns the current version of the reader module.

Command

Command	Data
'v'	None

Answer

Answer	Description
'MultiISO 1.0' + <CR> + <LF>	ASCII Mode
02 00 0C 4D 75 6C 74 69 49 53 4F 20 31 2E 30 1F 03	Binary Mode

Example

Command	Description
v	‘MultiISO 1.0’ Version of the reader module

Preliminary

12.4.3.22 Write block

This command writes data to a block. A read is done automatically after every write to ensure correct writing.

Command

Command	Data
'w'	Block address (1 byte), valid range 00h – 40h Data (n bytes)
'wb'	Block address (1 byte) Data (n bytes)

Answer

Answer	Description
Data	Data block (depends on tag type)
'F'	Error: Write failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure
'R'	Error: Out of range

Example

Command	Description
wb0511223344	Writes data 11223344 on block 05.

12.4.3.22.1 Write failure 'F'

This error is displayed if bad transmission conditions are given. If the block address exceeds the physical number of blocks of a tag, this error is shown.

12.4.3.22.2 No tag error 'N'

This error is returned if no tag is present or the card does not respond.

12.4.3.22.3 Operation mode failure 'O'

The presented tag is not ISO14443 type A, SR 176, ICode, ICode-UID and ISO 15693 compliant.

For ISO 14443 type A only Mifare tags are supported.

Preliminary

12.4.3.22.4 Out of range failure 'R'

The block address of the 'w' command is higher than 40h.

The block address of the 'w' command conflicts with other commands, therefore the block address has to be limited to 40h.

Use the 'wb' command instead.

12.4.3.23 Write EEPROM

Writes to the internal reader EEPROM. It contains all start-up parameters and the device ID. Changes to the start-up settings will only go into effect after a reset of the device.

Command

Command	Data
'wp'	Address (1 byte), valid range 0Ah - EFh Data (1 byte)

Answer

Answer	Description
Data	EEPROM data (1 byte)
'F'	Error: Read after write failure
'R'	Error: Out of range failure

Example

Command	Description
wp0A01	Set EEPROM address 0A (Station ID) to 01h

12.4.3.23.1 Out of range failure 'R'

The entered address exceeds the address range.

Preliminary

12.4.3.24 Reset

This command executes a power on (software) reset. New configuration settings will be loaded. It resets all tags in the antenna field.

Command

Command	Data
'x'	None

Answer

Answer	Description
MultiISO 1.0' + <CR> + <LF>	ASCII Mode
None	Binary Mode

12.4.3.24.1 Disable Start-up Message

If the start-up message is disabled in the protocol configuration register 2, the ASCII mode does not respond with the version of the reader.

12.4.3.24.2 Reset Timing

The power up timing depends on environmental conditions such as voltage ramp up. For handheld devices the timing can vary based on the charge state of the battery.

Preliminary

12.4.3.25 Field Reset

The field reset switches off the antenna field for the specified duration. All tags need a certain amount of time to initialize before a command can be processed. The second byte specifies the field recovery time.

Command

Command	Data
'y'	Off time in milliseconds (1 byte) Field recovery time in milliseconds (1 byte)

Answer

Answer	Description
'Y'	After the field reset the reader sends back a ‘Y’ to acknowledge the command.

Preliminary

12.4.4 ISO 14443 Type A (Mifare) only commands

12.4.4.1 Increment value block (credit)

Increments a value block with a defined value. A read is done automatically after a write to verify data integrity. The command fails if the source block is not in value block format. A previous login is needed to access a block.

Command

Command	Data
'+'	Block (1 byte) Value (4 bytes)

Answer

Answer	Description
Data	Value (4 bytes)
'I'	Error: value block failure
'F'	Error: increment failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure

Example

Command	Description
+0400000001	Adds 1 to value block 4
+0500000100	Adds 256 to value block 5

12.4.4.1.1 No value block 'I'

Specified block does not match the value format. The value block is corrupted. A backup block can be used to restore the correct value.

12.4.4.1.2 Increment failure 'F'

This indicates a general failure during the increment procedure or an inability to read after the write process.

Preliminary

12.4.4.1.3 No tag error 'N'

The reader does not detect a response from the tag. There is either no tag present or the tag does not respond to the request.

12.4.4.1.4 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

12.4.4.2 Decrement value block (debit)

Decrements a value block with a defined value. A read is done automatically after the write to verify data integrity. The command fails if the source block is not in value block format. A previous login is needed to access a block.

Command

Command	Data
'-'	Block (1 byte) Value (4 bytes)

Answer

Answer	Description
Data	Value (4 bytes)
'I'	Error: value block failure
'F'	Error: decrement failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure

Example

Command	Description
-0400000001	Subtract 1 to value block 4
-0500000100	Subtract 256 to value block 5

12.4.4.2.1 No value block 'I'

Specified block does not match the value format. The value block is corrupted. A backup block can be used to restore the correct value.

Preliminary

12.4.4.2.2 Decrement failure 'F'

This indicates a general failure during the decrement procedure or an inability to read after the write process.

12.4.4.2.3 No tag error 'N'

The reader does not detect a response from the tag. There is either no tag present or the tag does not respond to the request.

12.4.4.2.4 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

12.4.4.3 Copy value block (backup)

Copies a value block to another block of the same sector. A read is done automatically after the write to ensure data integrity. Used for backup and error recovery. A previous login is needed to access a block.

Command

Command	Data
'='	Source block (1 byte) Target block (1 byte)

Answer

Answer	Description
Data	New value of target block (4 bytes).
'I'	Error: value block failure
'F'	Error: copy failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure

Example

Command	Description
=0405	Copy value block 4 to block 5
=0506	Copy value block 5 to block 6

Preliminary

12.4.4.3.1 Target block

The target block does not need to be a valid value block. If the source block is not in value format, the command fails.

12.4.4.3.2 No value block 'I'

Source value block is not in a valid value block. The value block is corrupted. A backup block can be used to restore the correct value.

12.4.4.3.3 Copy failure 'F'

This indicates a general failure during the copy procedure or an inability to read after the write process.

12.4.4.3.4 No tag error 'N'

The reader does not detect a response of the tag. There is either no tag present or the tag does not respond to the request.

12.4.4.3.5 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

Preliminary

12.4.4.4 Login (authenticate tag)

Performs an authentication in order to access one sector of a Mifare® card. Only one sector can be accessed at a time.

Command

Command	Data
'l'	Sector (1 byte), valid range 00h - 3Fh Key type (1 byte) AAh authenticate with key type A FFh authenticate with key type A, transport key FFFFFFFFFFFFh BBh authenticate with key type B 10h … 2Fh authenticate with key type A using stored key (00h … 1Fh) 30h … 4Fh authenticate with key type B using stored key (00h … 1Fh) Key (6 bytes) / <CR> (1 byte), optional By transmitting <CR> instead of the keydata authentication is done with manufacturer's transport keys (A0A1A2A3A4A5h, B0B1B2B3B4B5h, FFFFFFFFFFFFh).

Answer

Answer	Description
data	Login status (1 byte)
'L'	Login success
'F'	Error: General failure
'N'	Error: No tag
'O'	Error: Operation mode failure
'R'	Error: Out of range
'X'	Error: Authentication failed

Preliminary

Example

Command	Description
l02AA<CR>	Authenticate for sector 2, using the transport key A (A0A1A2A3A4A5h, key type A)
l3FBB<CR>	Authenticate for sector 63, using the transport key 2 (B0B1B2B3B4B5h, key type B)
l04FF<CR>	Authenticate for sector 4, using the transport key 3 (FFFFFFFFFFFFh, key type A)
l0FAAFFFFFFFFFFFF	Authenticate for sector 15, using key FFFFFFFFFFFFh, key type A
l0E14	Authenticate for sector 14, using EEPROM key 4, key type A
l0530	Authenticate for sector 5, using EEPROM key 0, key type B
l0732	Authenticate for sector 7, using EEPROM key 2, key type B
l0110	Authenticate for sector 1, using EEPROM key 0, key type A
l0ABBFF12FFFFFF35	Authenticate for sector 10, using key FF12FFFFFF35h, key type B

12.4.4.4.1 No tag error 'N'

The reader does not detect a response from the tag. There is either no tag present or the tag does not respond to the request.

12.4.4.4.2 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

12.4.4.4.3 Out of range failure 'R'

The entered key type or the sector is out of range.

Preliminary

12.4.4.4.4 <CR>

Three transport keys are implemented to access cards quickly.

By transmitting <CR> instead of the key, the reader module uses the transport keys for the login procedure.

Command	Description
LxxAA<CR>	Authenticate for sector xx, using the transport key 1 (A0A1A2A3A4A5h, key type A)
LxxBB<CR>	Authenticate for sector xx, using the transport key 2 (B0B1B2B3B4B5h, key type B)
LxxFF<CR>	Authenticate for sector xx, using the transport key 3 (FFFFFFFFFFFFh, key type A)

12.4.4.4.5 Login with key data from EEPROM

Each key stored in the reader EEPROM can be used as type A or type B key. To use a key as type A, the value 10h must be added to the key index. 30h must be added to use a key as type B.

12.4.4.4.6 Usage of key A, key B

Mifare® cards support two different crypto keys for each sector. Each key is 32 bits long and is stored in the sector trailer (last block of the sector) on the card. It is possible to set different access rights for each key.

Preliminary

12.4.4.5 Read value block

Reads a value block. The command checks if data is in value block format. The read value block command needs a successful login.

Command

Command	Data
'rv'	Value block (1 byte)

Answer

Answer	Description
Data	Read value (4 bytes)
'F'	Error: General failure
'I'	Error: value block failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure

Example

Command	Description
rv04	Reads value of block 4.

12.4.4.5.1 No value block 'I'

The value read back after the write value command is not a value block. Data was written corruptly.

12.4.4.5.2 No tag error 'N'

This means that the tag does not respond, because either there is no tag present or none of the tags in the field are authenticated ('I' instruction).

12.4.4.5.3 General failure 'F'

In addition to the case of a data read failure caused by bad transmission conditions, this error is returned if a sector is addressed which is not located in the authenticated area.

12.4.4.5.4 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

Preliminary

12.4.4.6 Write value block

This command formats a block as a value block containing a 32-bit value. A read is performed automatically after the write. Value blocks need a complete 16-byte block due to redundant storage. A successful login is required to run the command.

Command

Command	Data
'wv'	Value block (1 byte) Value (4 bytes)

Answer

Answer	Description
Data	Written value (4 bytes)
'I'	Error: value block failure
'F'	Error: write failure
'N'	Error: No tag in field
'O'	Error: Operation mode failure

Example

Command	Description
wv05010055EF	Writes value 010055EFh to block 5.

12.4.4.6.1 Invalid value 'I'

The value read back after the write value command is not a value block. Data was written corruptly.

12.4.4.6.2 Write failure 'F'

In addition to the case of a data read failure caused by bad transmission conditions, this error is returned if a sector is addressed which is not located in the authenticated area.

12.4.4.6.3 No tag error 'N'

This error is returned if no tag is present or the card does not respond.

Preliminary

12.4.4.6.4 Operation mode failure 'O'

The tag is not ISO14443 type A compliant.

12.4.4.6.5 Writing values

The write value block command is designed to create blocks in value format. This command requires write access to the specified block. Using this instruction for ticketing operations is not recommended. For ticketing applications, special instructions (Increment/Decrement/Copy) are available.

Preliminary

12.4.5 Key Management

The Key Management is able to store up to 32 keys and is also able to manage 3 different key types.

If no key is available to login into the reader, it is possible to reset the key table without any authentication.

Key type	Description
01	my-d Secure key
02	DES key
03	Mifare key

12.4.5.1 Authenticate to reader

This command logs into a reader. Only my-d Secure and DES keys are allowed to login into reader. After successful log in the key table of the reader can be changed. The authentication does 2 two-pass authentications, defined in ISO 9798 part 2, within two steps. Following commands need a prior log in:

- Update key
- Update key access rights
- Change key type
- Reset key table

Command

Command	Data
Step 1: 'ar'	Option x1h (1 byte) Key type (1 byte) Key index (1 byte)
Step 2: 'ar'	Option x2h (1 byte) Random number key Management (8 bytes) MAC key Management (8 bytes)

Answer

Answer	Description
Step 1	Random number reader (8 bytes)
Step 2	MAC reader (8 bytes)

Preliminary

Option

The option byte defines the authentication step and type of authentication.

Bit	Description
0 - 1	Authentication Steps 0: Log out 1: Step 1 2: Step 2
2 – 6	RFU
7	Authentication Algorithm 0: 2 two pass authentications 1: RFU

Key index

The key index of Step 1 points to a valid key with the access rights to login into the reader.

The key index is zero based.

Log out

It is possible to log out with Authentication Step 0.

Default Keys

The following keys are default:

Key Type	Key
my-d	01020407080B0D0E10131516191A1C1Fh Default Master key
DESFire	00000000000000000000000000000000h
Mifare	A0A1A2A3A4A5h
Mifare	B0B1B2B3B4B5h
Mifare	FFFFFFFFFFFFh

Preliminary

Two-Pass Authentication Flow Diagram

Host		**Reader**
1. Start Authentication Step 1	StartAuth →	
		2. Generate Random number RndRdr
	← RndRdr	3. Reply Random number
4. Generate Random number RndH		
5. Calculate the MAC of the key management MacH = Enc(RndRdr)		
6. Transmit Random number and MAC: RndKm,MacH	RndKm,MacH →	
		7. Check the received MacH RndRdr = Dec(MacH)
		8. Calculate the MAC of the reader MacRdr = Enc(RndH)
	← MacRdr	9. Reply MAC
10. Check the received MacRdr RndH = Dec(MacRdr)?		

Preliminary

12.4.5.2 Get Key Access Rights

This command returns the access rights of a key.

Command

Command	Data
'ia'	Key type (1 byte) Key index (1 byte)

Answer

Answer	Description
Data	Access rights (2 bytes). Higher Byte is send first

Access Rights

Only the default master key has all access rights. New keys got the default value 0000h.

Bit	Description
0	Allow Add Key
1	Allow Update Key
2	Allow Delete Key
3	Allow Reset Key table
4 - 7	RFU
8	RFU (Disable Serial Encryption)
9	Disable Authentication Tag
10	Allow Authentication Reader
11	Allow Changing Access rights
12	Allow Key Type changing
13	Allow 'ds' encryption
14 - 15	RFU

Preliminary

12.4.5.3 Get key status

This command reports the key status of the reader. The reader lists for each key the key information. This command is used to inform the key management about the key status. The first byte of the response lists the number of stored keys.

Command

Command	Data
'it'	key type (1)

Answer

Answer	Description
my-d Secure Data	Number of keys (1 byte) [Key information (8 bytes)] • Free User part (1 byte) • Project ID (3 bytes) • Logical Sector ID (1 byte) • Key type (1 byte) • KVV (2 bytes)
DES Data	Number of keys (1 byte) [Key information (10 bytes)] • Option byte (1 byte) • Free User part (9 bytes)
Mifare Data	Number of keys (1 byte) [Key information 10 bytes)] • Free User part (10 bytes)

More than 255 bytes

If the amount of data exceeds 255 bytes, than the answer is divided into more frames.

If a frame follows, the Number of keys byte is extended with a set MSB (80h).

Preliminary

12.4.5.4 Reset key table

The reset key table clears all key entries in the reader. Afterwards the default keys are loaded automatically.

It is only allowed to reset the key table after a successful authentication to the reader.

If no keys are available to login into the reader, it is possible to reset the key table without an authentication.

Command

Command	**Data**
‘rt’	None

Answer

Answer	**Description**
‘RT’	In case of success

Preliminary

12.4.5.5 Update key access rights

This command is able to change the access rights of a key.

It is only allowed to change the access rights after a successful authentication to the reader with a key permitted to change the access rights.

Command

Command	Data
‘ua’	Key type (1 byte) Key index (1 byte) Access rights (2 bytes)

Answer

Answer	Description
Data	Access rights (2 bytes). Higher Byte has to be sent first.

Access rights

For more detailed information refer to "Get key access rights".

Preliminary

12.4.5.6 Change key type

This command is able to change the key type. Be sure the key information data are suitable to the key type.

It is only allowed to change the key type after a successful authentication to the reader with a key permitted to change the key type.

Command

Command	Data
‘uc’	Key type (1 byte) Key index (1 byte) New key type (1 bytes)

Answer

Answer	Description
Data	Access rights (2 bytes)

Preliminary

12.4.5.7 Update key

The update key command stores, modifies or deletes a key in the reader key table. A key is identified with its key information data. The key information data has to be unique within the same key type.

If a key is erased the key data must be dropped.

It is only allowed to update the key type after a successful authentication to the reader with a key permitted the necessary rights.

Command

Command	**Data**
my-d Secure 'uk'	Key type 01h (1 byte) Action (1 byte) Key information data (8 bytes) • Free User Part (1 byte) • Project ID (3 bytes) • Logical Sector ID (1 byte) • Key type (1 byte) • KVV (2 bytes) Key Data (8 / 16 bytes)
DES 'uk'	Key type 02h (1 byte) Action (1 byte) Key information data (10 bytes) • Option (1 byte) • Free user part (9 bytes) Key Data (16 bytes)
Mifare 'uk'	Key type 03h (1 byte) Action (1 byte) Key information data (10 bytes) • Free user part (10 bytes) Key Data (16 bytes)

Answer

Answer	**Description**
Data	Index of key (1 byte)

Preliminary

Action

The Action byte defines the action of the key.

Action	Description
Axh	Add / Update key
5xh	Delete Key
x1h	my-d Secure key A
x2h	my-d Secure key B

my-d Secure key

For more detailed information on key information data refer to Infineon documentation.

DES key option byte

Bit	Description
0	0 … 16 byte key 1 … 8 byte key
1 - 7	RFU

In case of an 8-byte key, the first 8 bytes of the key data are valid.

Mifare key

Only the first 6 bytes of key data are valid.

Number of stored keys

The key management is able to store up to 32 keys.

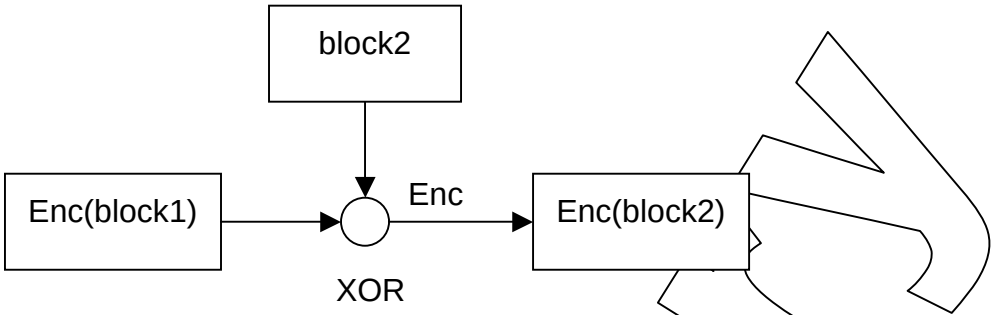
Encryption

Key Data for DESFire and Mifare keys has to be encrypted with the login key in CBC mode. my-d S keys are enciphered every 8 byte block separately without CBC mode.

CBC mode

The data stream has to be divided into blocks of 8 bytes. The last enciphered block has to be XORed with the next plain block.

Preliminary



12.4.6 my-d Secure

Note that ISO 14443 tags do not support the addressed mode. Bit 5 and 6 of the option byte are not used with ISO 14443 tags. The ISO 14443 tag only works in selected mode.

12.4.6.1 Abort KTT upload

This command aborts the Prepare for KTT 'ut' command, if the reader is in prepare for KTT awareness mode.

Command

Command	**Data**
'*'	None

Answer

Answer	**Description**
00h	Prepare for KTT successfully aborted
'F'	Prepare for KTT was not active
No response	Key uploading is in progress

12.4.6.2 Authenticate to sector

The Authenticate to sector command sets up a secured transmission to a transponder.

Preliminary

Command

Command	Data
‘as’	Option byte (1 byte) [UID (8 bytes)] Key page (1 byte) Key index (1 byte) Counter page (2 byte) Diversification data (8 bytes)

Answer

Answer	Description
‘L’	In case of success

Option byte

The option byte defines the general behavior of the command.

Note that ISO 14443 tags are only working in selected mode.

Bit	Description
7	RFU
6	If set the tag is in addressed mode. The UID is following as first 8 bytes after the option byte. The my-d frame is following.
5	If set the tag is selected. No UID is needed.
4 - 0	RFU

Key page

This byte defines the key page number of the transponder

Key index

Defines the reader key index. If the index exceeds the key index of the reader the error ‘R’ out of range is thrown. The key index is zero based.

Counter page

This page number points to the authentication counter page. Lower byte of the page number is sent first.

Preliminary

Diversification data

This data is used to diversify the key data.

Example

Command	Answer / Description
'as20040103000000000000000000'	'L' Login into tag.

12.4.6.3 Issue transponder key

Writes a diversified key to the transponder.
This command uses the write and Reread my-d command.

Command

Command	Data
‘ik’	Option byte (1 byte) [UID (8 bytes)] Key index (1 byte) Destination page (2 bytes) Diversification data (8 bytes) [Sector index and access conditions (2 bytes)]

Answer

Answer	Description
‘IK’	Key successfully written

Preliminary

Option byte

The option byte defines general behavior of the command.

Note that ISO 14443 tags are only working in selected mode.

Bit	Description
7	If set the user mode is used and the MAC is calculated and added to the frame. If not set the issuer mode is used sector index and access conditions are included and no MAC is calculated.
6	If set the tag is in addressed mode. The UID is following as first 8 bytes after the option byte. The my-d frame is following.
5	If set the tag is selected. No UID is needed.
4 - 0	RFU

Key index

Defines the reader key index. If the index exceeds the key index of the reader the error ‘R’ out of range is thrown. The key index is zero based.

Destination page

Defines the transponder page index. Lower byte of the page number is sent first.

Sector index and access conditions

In issuer mode the sector index and the access conditions are added.

12.4.6.4 Prepare for KTT

This command sets the reader into KTT awareness mode.

Command

Command	Data
‘ut’	Key page (1 byte) Key index (1 byte) Counter page (2 bytes) Diversification data (8 bytes)

Answer

Use the check KTT upload status ‘!’ command to finish the upload procedure.

Preliminary

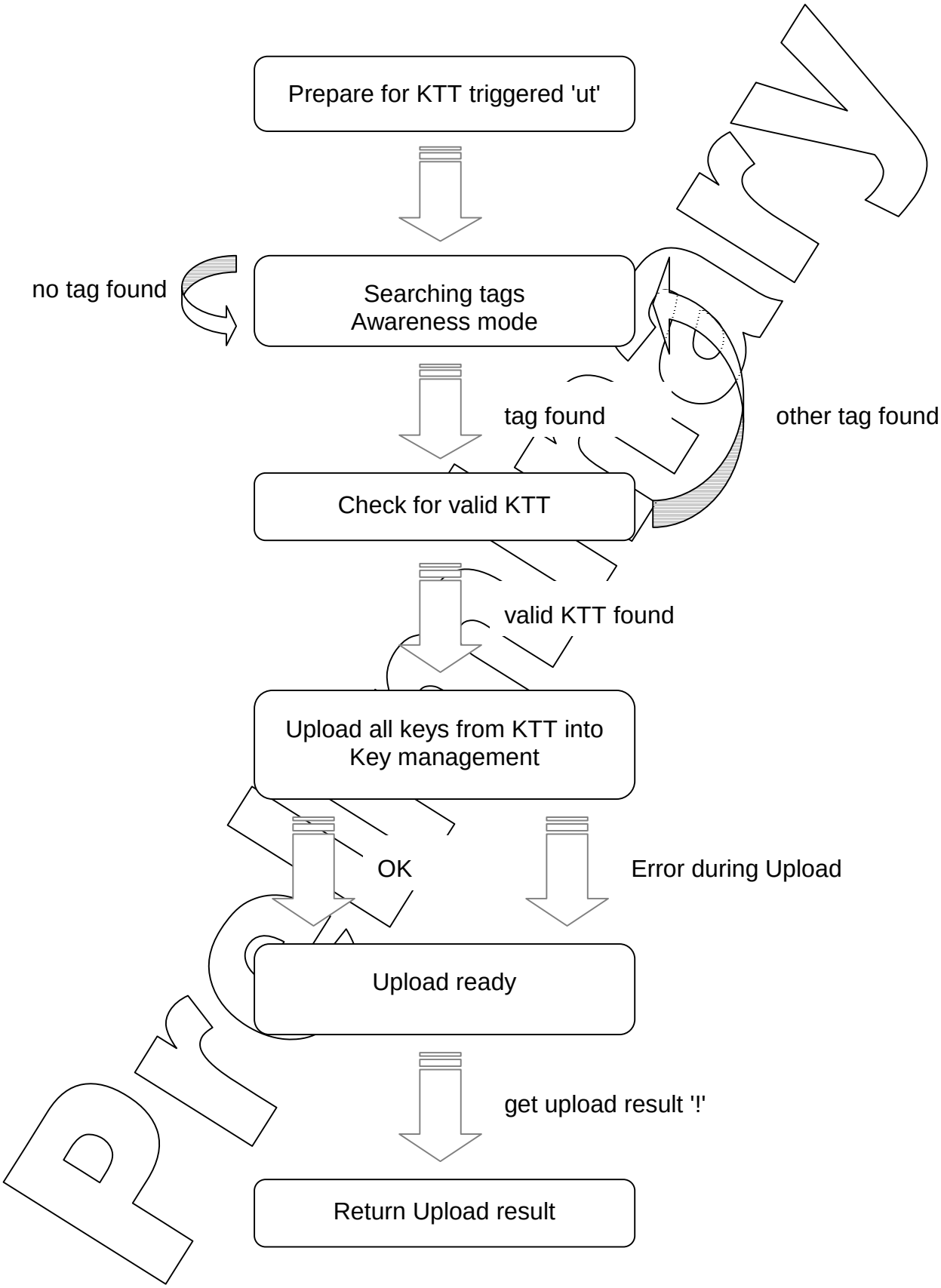
LED activity

The green and red LED indicates the state of the upload process.

Mode	**LED activity**
Awareness	Red and green LEDs are flashing slow
Upload in progress	Green LED is active
Error during upload detected	Red LED is flashing fast until the ‘!’ command is received
Upload finished successfully	Green LED is flashing fast until the ‘!’ command is received
Upload aborted	Red LED is active for 1 second

Preliminary

State diagram



Privacy

12.4.6.5 my-d command

This command sends and receives my-d Plain and Secure commands including my-d secure algorithm.

Command

Command	Data
‘z’	Downlink length (1 byte) Option byte (1 byte) [UID (8 bytes)] my-d data (n bytes)

Answer

Answer	Description
Data	Status byte: 00h (1 byte) Data without MAC and CRC (n bytes)

Downlink length

This byte is mandatory. It will define the length of the my-d data frame sent to the reader. The MAC, CRC and the framing overhead is not included.

Option byte

The option byte defines general behavior of the command.

Note that ISO 14443 tags are only working in selected mode.

Bit	Description
7	If set the MAC is calculated and added to the frame
6	If set the tag is in addressed mode. The UID is following as first 8 bytes after the option byte. The my-d frame is following.
5	If set the tag is selected. No UID is needed.
4 - 0	RFU

Preliminary

Data

Data is sent as my-d plain command. It contains only data that is processed by the MAC calculation. If the tag is addressed, only valid with ISO 15693 tags, with its UID the first 8 bytes are interpreted as UID and not included into the MAC calculation.

MAC calculation is done automatically if according flag is set. The ISO 15693 or the ISO 14443 frame is completed and the CRC is computed and added automatically.

The commands Write Page, Restricted Write and Write Byte do not need any MAC verification for the answer.

Preliminary

13 Frequently Ask Questions

13.1 Getting Started

To test and interface the Dual ISO Module, you do not need a sophisticated µP development system. All you need is a PC, a connection cable and a power supply for the reader. If you are using Microsoft Windows (95/98/NT/…), take the following steps:

- Make sure, that your reader has an RS232 interface
- Start HyperTerminal
- Create a new connection (FILE/NEW CONNECTION)
- Enter a name for the connection (i.e. ‘MIFARE’)
- Select connect COM2 (COM1) direct connection
- Connection setup 9600,8,n,1,no handshake
- Connect your reader to COM2 (COM1) of the PC and apply appropriate supply voltage. The reader transmits a string (“MultiISO 1.0”) to the PC.
- This string denotes the firmware provided with your reader module
- Put a tag to your reader. Serial numbers should be displayed properly
- Enter commands via keyboard. They should be transmitted to the reader and the reader should reply

If using an operating system different from Microsoft Windows, you may use any other terminal program that is capable of receiving/transmitting data via the serial port of your PC.

13.2 How should the Multi ISO Reader be personalized?

In ASCII protocol applications, no personalization is necessary.

In applications that are using the binary protocol mode, personalization is required. Use the Utility program to set up your reader correctly. Ask the reseller or the ACG ID sales representative for the Utility software or download it from http://www.acg.de. Minimum requirements are WIN98SE, WIN 2000, WIN XP and a free COM port on the PC.

Preliminary

13.3 What type of Mifare® card should I use?

The Mifare® standard is designed for multi-application environments. It contains 16 sectors each with 2 individual keys, access conditions, and 3 data or value blocks. Some applications use the 1 Kbytes of the Mifare® Standard Card Memory only as storage area.

Mifare Ultralight has no crypto unit on chip. It only supports 16 blocks.

Mifare Standard 4k cards have the same features as Mifare Standard cards but increased memory capacity.

13.4 How safe is Mifare® Standard for cashless payment?

Security is always a feature of the overall system, not of the components. It requires careful design.

A properly designed system will require **ALL** barriers to be hacked in order to be broken.

For good design start identifying possible attacks and then create barriers to block them.

Mifare® was specifically designed for cashless payment applications. The Mifare® concept provides the following security barriers:

- Anti-collision/-selection
- Atomic value transaction
- Ciphered communication
- Storage of values and data protected by mutual authentication
- Weak field keys that allow decrement only
- Stored keys in the reader that are not readable
- Keys in the card that are not readable
- A brute force attack based on trying many different keys is limited by the transaction time (several ms) of the card and would last virtually forever.

Preliminary

The Application can and should provide more barriers:

- Sector access conditions. It is possible to assign access conditions in a way that only decrementing of values is allowed with the keys used in the field. So even a manipulated field station cannot be used to increment the value on the cards. As a general rule, key A is used as a field key, allowing only to read and decrement values, and key B is used to format the card or increment values.
- Diversified keys. To make life even harder for attackers, keys can be modified using the serial number and memory content of the card. So each card uses different keys and a listening attack on the reader interface would be hopeless.
- Limiting cash volume stored on a card
- Do not use the transport keys (keys programmed at the time of delivery) for ticketing applications!
- Ciphered and scrambled data storage
- Sabotage alarm
- Even higher security with contact less controller cards like DESFire, Mifare ProX, Smart MX etc.

Preliminary

13.5 Using a Mifare card

This example demonstrates the detection of a card in the antenna field with continuous read and the reading of a page.

Command	**Answer**
c	Activate continuous read mode
	B2197B58 a card responds with its serial number
.	S abort continuous read mode
s	B2197B58 select card
l01AAFFFFFFFFFFFF	L login into sector 1 with key FFFFFFFFFFFFh key type A
rb04	00112233445566778899AABBCCDDEEFF read block 04
c	Activate continuous read mode to detect a new card

Figure 13-1: Using a Mifare card

Preliminary

13.6 Using a DESFire card

13.6.1 Create a plain standard data file

After activation, application 0 is selected automatically. Default access rights of application 0 require a login to create an application. The following example illustrates the successful creation of a plain standard data file.

Command	Answer
s	04E10E00000000 activate card
f12000000000000000000000000000000000000000	L login to application 0
f06050000100F01	00 create application with ID 000010
f0408000010	00 select application with ID 000010
f080F0000eeee10000000	00 create plain standard data file with ID 00

Figure 13-2: Create plain standard data file of a DESFire card

13.6.2 Use a plain standard data file

The next example demonstrates the use of a plain standard data file, such as that created in the previous example. No login needed since the file is plain.

Command	Answer
s	04E10E00000000 activate card
f0408000010	00 select application with ID 000010
f020D00	00 select file with ID 00
f0916000001122334455	00 write data to standard data file
f051500000010	00112233445500000000000000000000000000 read data from standard data file

Figure 13-3: Change data of a plain standard data file

Preliminary

13.6.3 Create a value file

Basically, each application is created in the same way. The access rights of an application can be adjusted to freeze the application organization. In this case, a login to the application is needed to make any changes to the application. Regardless of the application access rights, a file can be selected using its ID. Before accessing a secured file, a login to the application is needed. A successful login allows changing all the files in the application that use the same key.

A value file has a special structure. If a value file is changed the changes are only accepted after a commit transaction command. This feature allows modifying several files of an application and changing all the contents at the same time.

The following example illustrates the creation of a value file using DES encipher.

Command	**Answer**
s	04E10E00000000 activate card
f12000000000000000000000000000000000000000	L login to application 0
f06050000110F01	00 create application with ID 000011
f0408000011	00 select application with ID 000011
f12110003000000000000FFFFFF7Ff5555555500	00 create value file with initial value 55555555 with ID 00. File is secured with DES encipher

Figure 13-4: Create a plain standard data file on a DESFire card

Preliminary

13.6.4 Use a DES secured value file

The next example demonstrates the use of a DES secured value file, such as the one created in the previous example. After the selection of the application, a login with the key of the value file is needed to access the file. Modification of the value file is accepted after the commit transaction command is given.

Command	**Answer**
s	04E10E00000000 activate card
f0408000011	00 select application with ID 000011
f03000000	L login to application
f020D00	02 select file with ID 00 (value file)
f0117	0055555555 read value file data
f051911111111	00 debit value file with 11111111
f0117	0055555555 read value file, no modification done
f011c	00 commit transaction, modification is done
f0117	0044444444 read value file, verify modification

Figure 13-5: Change data of a plain standard data file

Preliminary

14 References

[1] ISO/IEC 14443 Part 1-4, Identification Cards – Contact less integrated circuit(s) cards – Proximity cards

[2] DESFire Documentation, Philips, http://www.semiconductors.philips.com

[3] Data Encryption Standard (DES), FIPS PUB 46-3, Reaffirmed 1995 October 25

[4] ACG Antenna Design Guide

[5] Philips; Application Note, Mifare® & I-Code, Micore Reader IC family Directly Matched Antenna Design

Preliminary

15 Appendix A: Antenna

According to antenna design, please refer to the Philips Application Note (Mifare ® & I-Code, Micore Reader IC family Directly Matched Antenna Design) or to the ACG Antenna Design Guide.

Preliminary

16 Appendix B: SAM

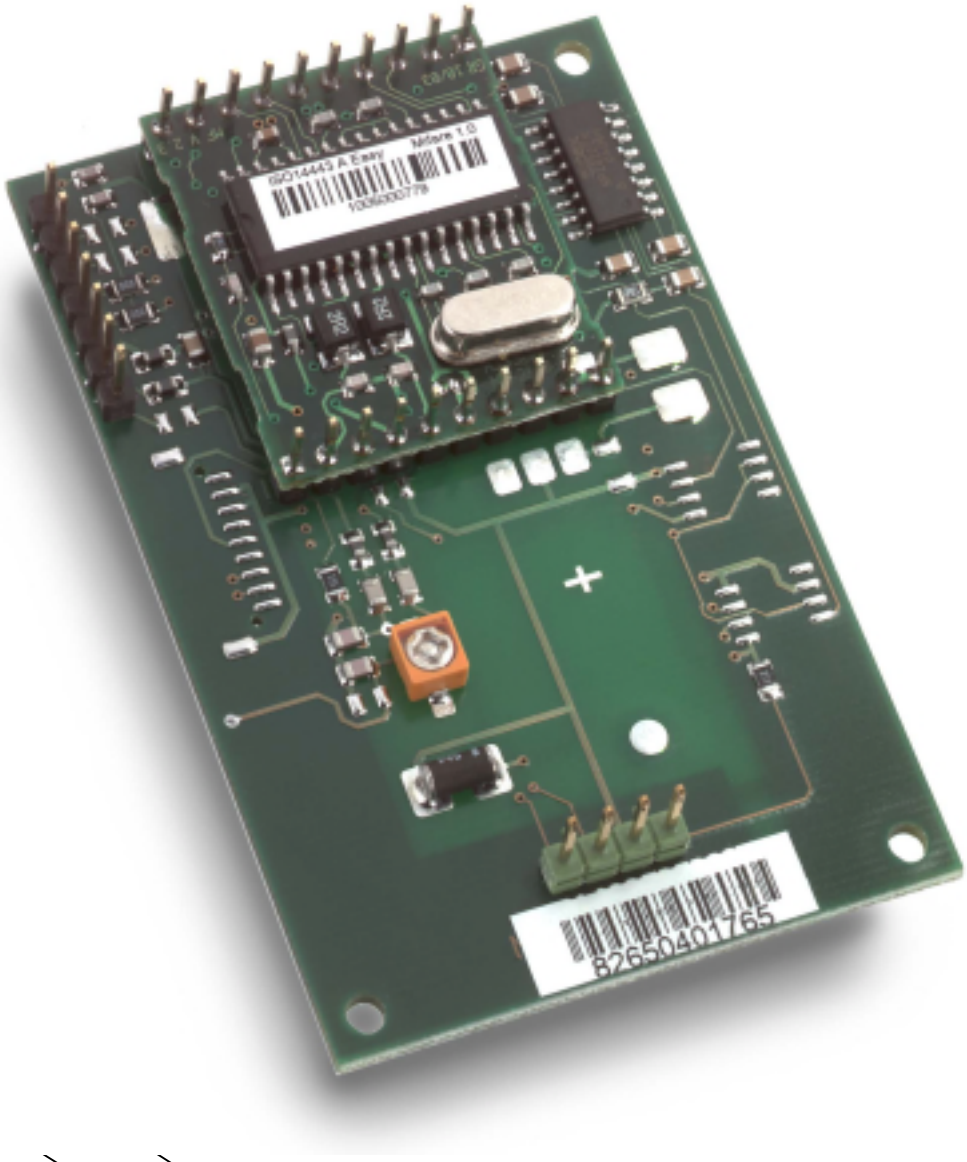
Please note that the power supply of the SAM adapter must be turned off during the entire card insertion period, otherwise SAM card damage might occur.

For proper usage of the SAM, a 100nF capacitor between V_{cc} and GND is necessary.

Preliminary

17 Appendix C:

17.1 Compact Serial Plug & Play Module (RDHC-0202N0-01)



17.1.1 Features

- Interface type: RS232
- Dimensions: 70x45x12.1 (LxWxH), all in mm
- Reading Distance: up to 85mm, depending on the tag
- SAM: supported
- Boot loader: supported (²)
- Drivers: virtual COM port driver, DLL driver available
- Antenna: on board
- Signaling: reading LED, power LED
- Power Supply: 5VDC ± 10% regulated

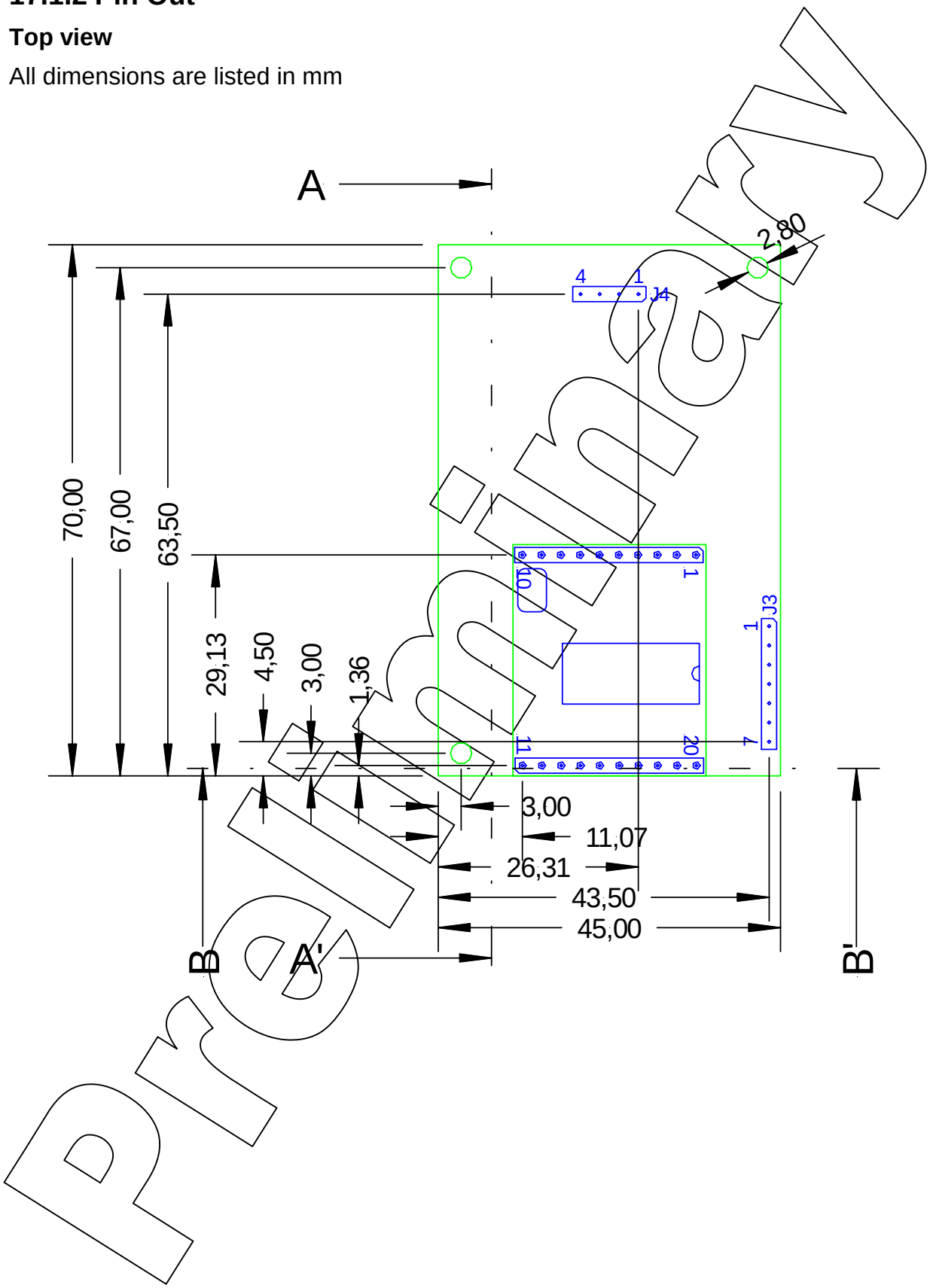
(²) The boot loader enables to download a firmware update via the serial interface to the unit without replacing/dismantling the hardware.

Preliminary

17.1.2 Pin Out

Top view

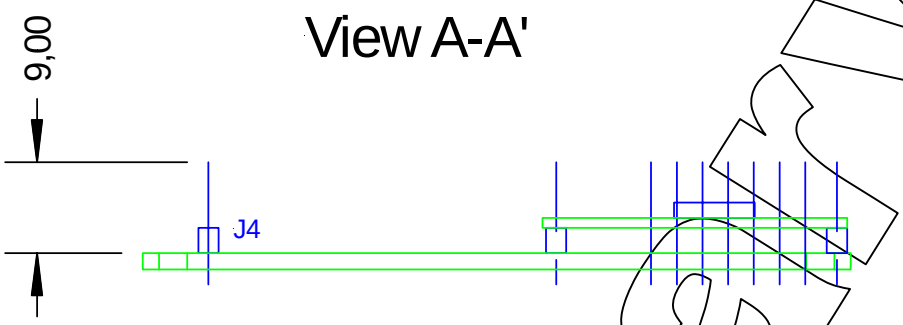
All dimensions are listed in mm



Preliminary

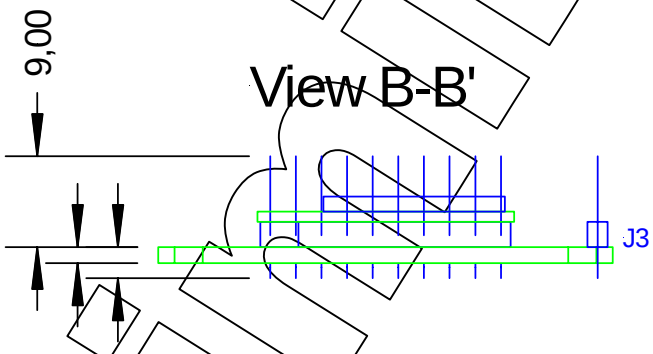
Side View

All dimensions are listed in mm



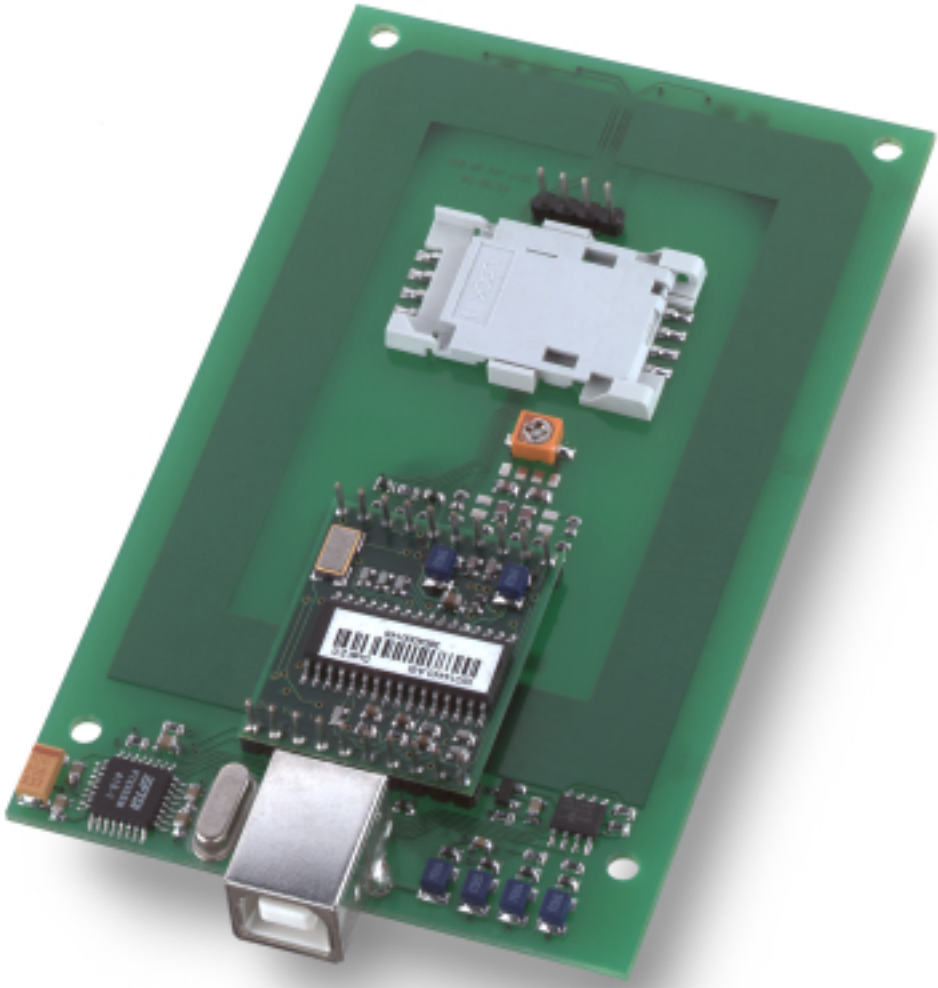
Front View

All dimensions are listed in mm



Preliminary

17.2 Short Range Plug & Play Module (RDHS-0204N0-01)



17.2.1 Features

- Interface type: USB 2.0
- Dimensions: 110x70x14 (LxWxH), all in mm
- Reading Distance: up to 90mm, depending on the tag
- SAM: supported
- Boot loader: supported (²)
- Drivers: virtual COM port driver, DLL driver available
- Antenna: on board
- Signaling: reading LED, power LED
- Power Supply: via USB

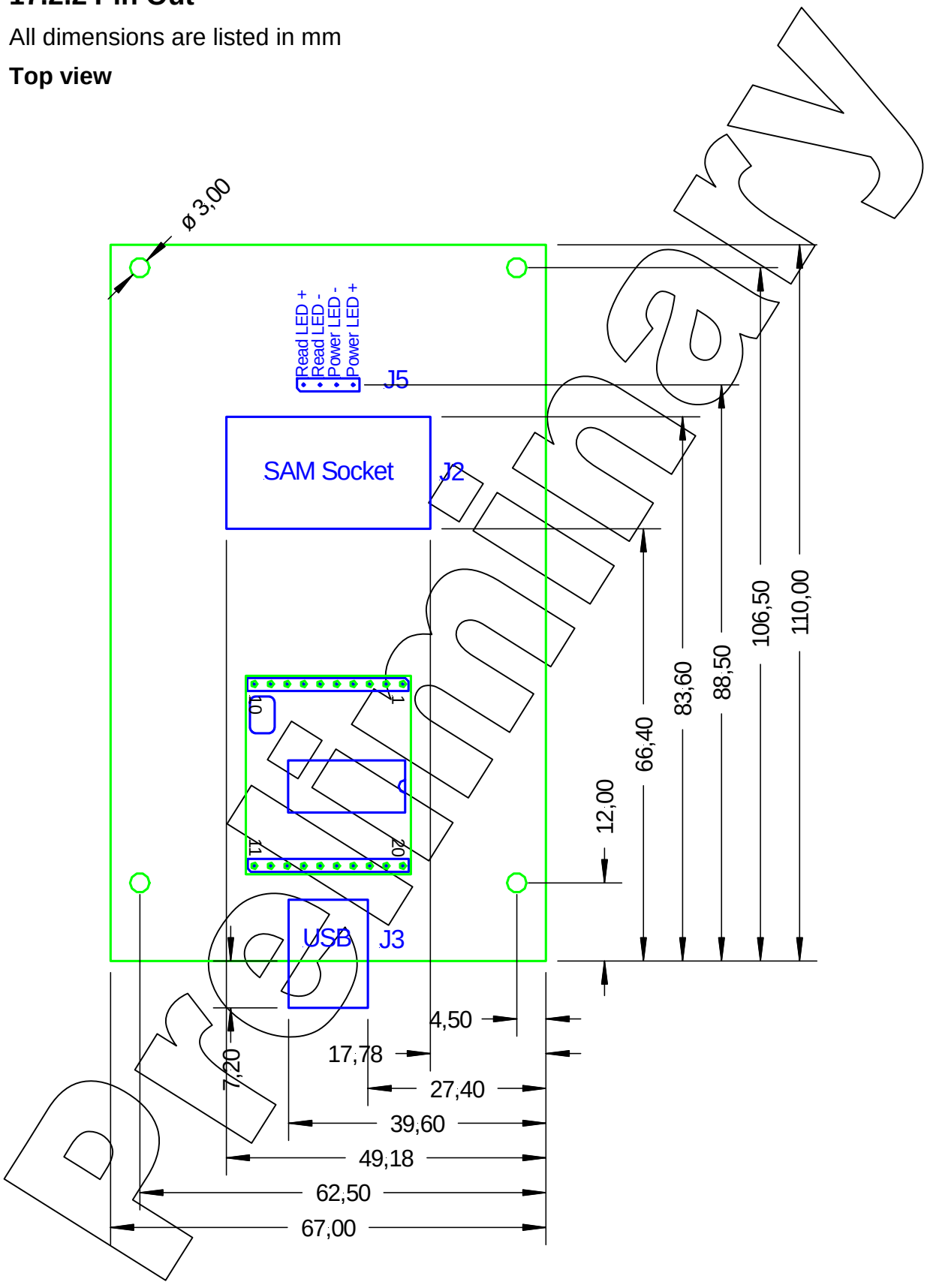
(²) The boot loader enables to download a firmware update via the serial interface to the unit without replacing/dismantling the hardware.

Preliminary

17.2.2 Pin Out

All dimensions are listed in mm

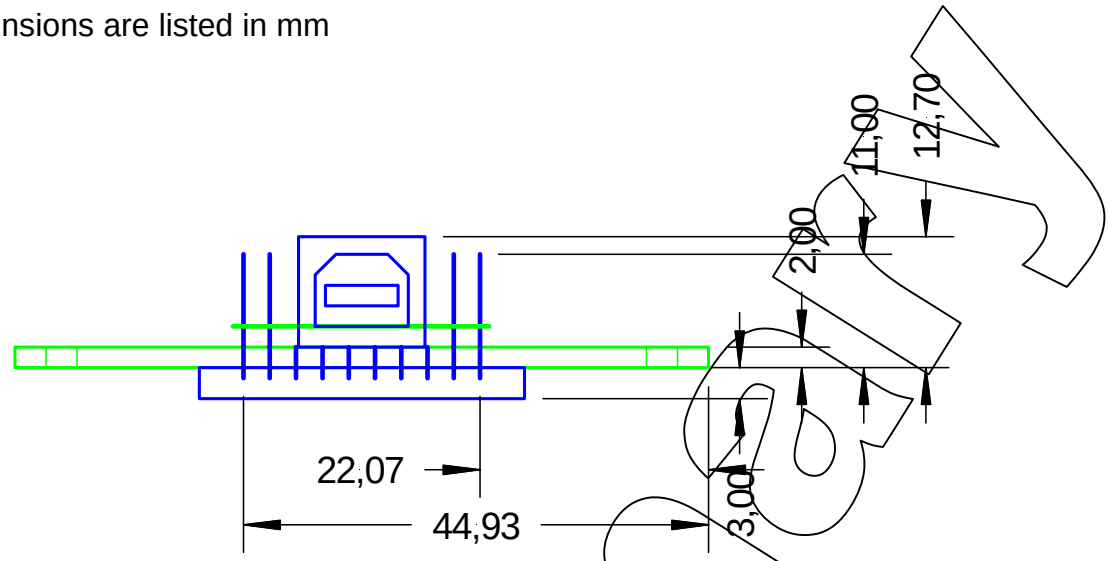
Top view



Preliminary

Front View

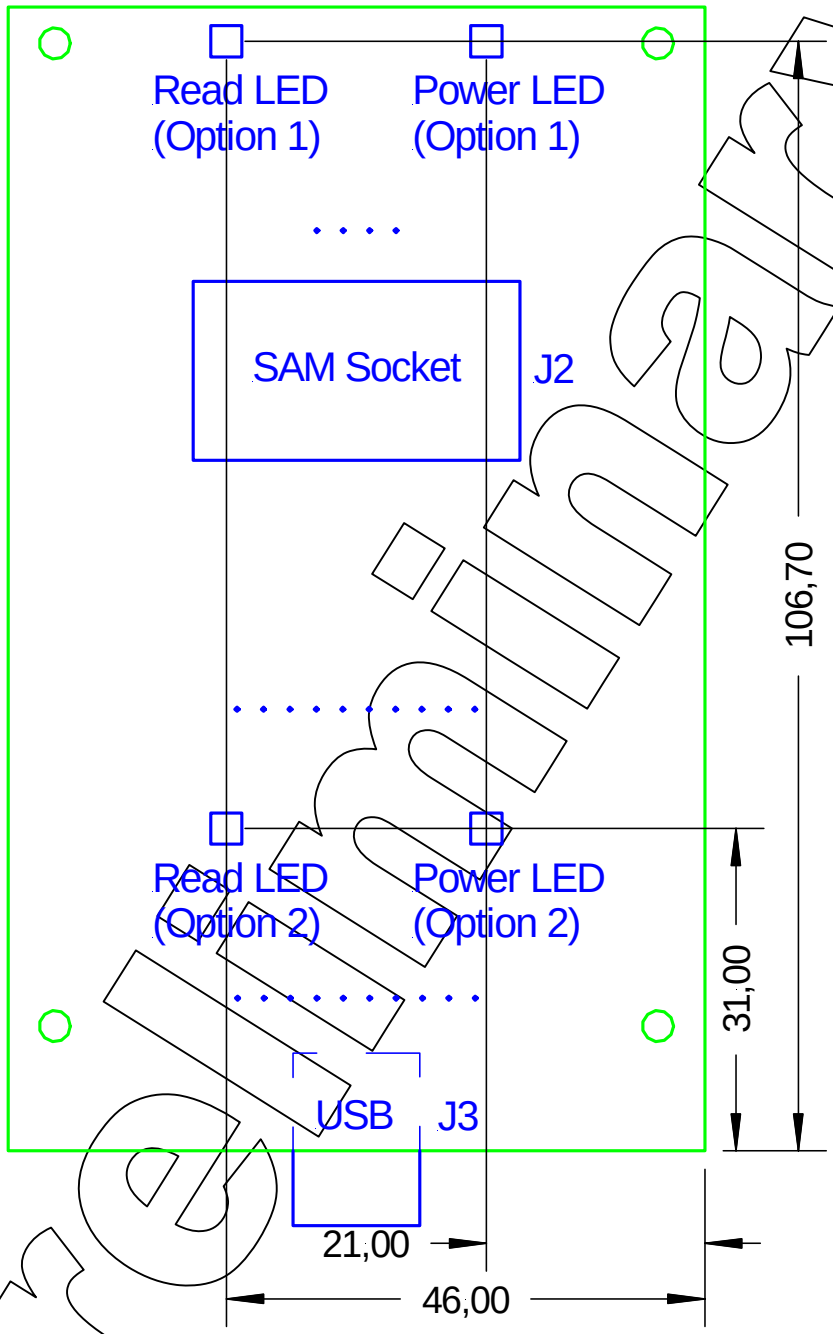
All dimensions are listed in mm



Preliminary

Bottom view

All dimensions are listed in mm



Preliminary

17.3 Short Range USB Desktop Reader (RDHS-0204D0-01)

Pre

17.3.1 Features

- Interface type: USB 2.0
- Dimensions: 155x82x35 (LxWxH), all in mm
- Reading Distance: up to 90mm
- SAM: supported
- Boot loader: supported (²)
- Drivers: virtual COM port driver, DLL driver available
- Antenna: on board
- Signaling: reading LED, power LED
- Power Supply: via USB

(²) The boot loader makes it easy to download a firmware to the unit without replacing/dismantling the hardware.

Preliminary

17.4 CF Card Reader (RDHP-0206P0-01)

Pre

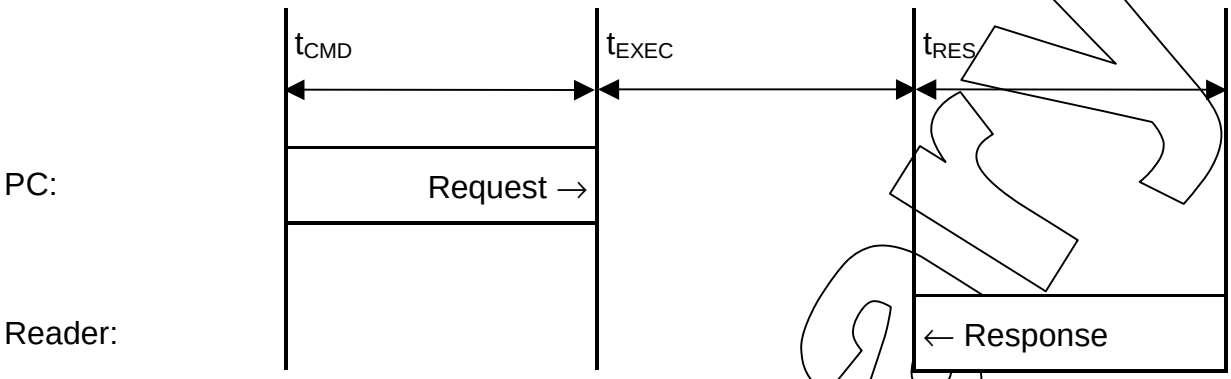
17.4.1 Features

- Interface type: CF Card Type II
- Dimensions: 43.0 x 84.0 x 7.0 (LxWxH), all in mm
- Reading Distance: up to 65mm
- SAM: not integrated
- Boot loader: supported (²)
- Drivers: virtual COM port driver, DLL driver available
- Antenna: integrated
- Signaling: reading LED integrated
- Power Supply: via CF Card Interface

(²) The boot loader makes it easy to download a firmware to the unit without replacing/dismantling the hardware.

Preliminary

18 Appendix D: Timings



Command	t_{EXEC} [ms]	Comments
Common commands		
Cont. read (locked tag)	2.8 – 22.6	+ Reset Off and Recovery Time
Cont. read (worst case)	54	+ 3x Reset Off and Recovery Time
DES en/decryption	9.6 – 9.7	
TDES en/decryption	28.7 – 28.8	
Highspeed select 'h08' (locked tag)	8.9 – 14.4	+ Reset Off and Recovery Time + SFGT
Highspeed select 'h08' (no tag)	15	+ 3x Reset Off and Recovery Time
Highspeed select 'h08' (worst case)	14.7	+ 3x Reset Off and Recovery Time + SFGT
Multiselect (locked tag)	5.8 – 11.4	+ Reset Off and Recovery Time
Multiselect (no tag)	67	+ Reset Off and Recovery Time
Multiselect (worst case)	67	+ Reset Off and Recovery Time
Antenna on	0.2	+ Reset Recovery Time
Antenna off	0.2	
Port read	0.1	
Port write	0.1	
Read block	1.8 – 2.2	
Write block	8.2 – 11	
Reset	13.2	
Select (locked tag)	5.4 – 22.8	+ Reset Off and Recovery Time
Select (no tag)	38	+ 3x Reset Off and Recovery Time
Select (worst case)	55	+ 3x Reset Off and Recovery Time

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ISO 14443 Type A only commands		
Increment value block	18.4	
Decrement value block	18.4	
Copy value block	18.5	
Read value block	2.3	
Write value block	7.9 - 10.5	
Mifare Login	4.9	
Power conditions		
Power on	79	Does not include rise time of power supply
Enable on	85	

Figure 18-1: Timings

Default Command Guard Time (20h = 1.2ms) was used.

All timing data is advisory application information and does not form part of the specifications. It may change in future firmware releases. Please also note that all values specified in the above table depend on the tag used and Command Guard Time.

Preliminary

19 Appendix E: Release Notes

19.1 Version History

19.1.1 MultiISO 1.0

Initial Release.

Preliminary

19.2 Revision history

Date	Revision number
09/02/2005	Version 1.0, Rev. 1.0

Preliminary

20 Appendix F: Approvals / Certificates

20.1 CE Declaration

The ACG HF Multi ISO Reader Module complies with the European CE requirements specified in the EMC Directive 89/336/EEC.

If the ACG HF Multi ISO Reader Module is operated with other components, all power connections and additional components of the final device must comply with the European EMC directive.

Additional connections may have a length of up to 2 m maximum, or in fixed installations up to 1 m maximum.

European customers must themselves make sure that the final device conforms to the European EMC Directive.

Preliminary

20.2 FCC Declaration

The ACG HF Multi ISO Plug & Play Modules and the CF Card Reader Module comply with the US FCC Part 15 requirements. The relevant documents are available.

If any of the Multi ISO Plug & Play Modules or the CF Card Reader Module is operated from a mains power supply, all power connections and additional components of the final device must also comply with the US FCC Part 15 directive.

Customers selling into the USA must themselves make sure that the final device conforms to the US FCC Part 15 directive.

Preliminary

20.3 Mifare Certificate

The ACG HF Multi ISO Plug & Play Modules and the CF Card Reader Module comply with the Philips Mifare requirements. The units have shown their compliance during extensive tests at the Arsenal Research Institute, located in Vienna/Austria. Arsenal Research is the official Mifare certification institute.

Preliminary